

Epidemiology and Risk Factors of Scrub Typhus in Punjab, India: A Matched Case-Control Study, 2018

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ABSTRACT

Background: Scrub typhus is an acute febrile zoonotic infection caused by *Orientia tsutsugamushi* and transmitted through the bite of infected larval trombiculid mites. The disease has increasingly been reported from several ecological regions of India, including Punjab. However, evidence regarding community-level risk factors for scrub typhus in Punjab remains limited. **Objectives:** To identify environmental, occupational and behavioural risk factors associated with scrub typhus in selected districts of Punjab and to recommend appropriate preventive and control measures. **Methods:** A concurrent 1:2 matched case-control study was conducted from June to November 2018 in five districts of Punjab: Hoshiarpur, Rupnagar, Shahid Bhagat Singh Nagar, Sahibzada Ajit Singh Nagar and Fatehgarh Sahib. Cases were residents of the selected districts who tested positive for scrub typhus by immunoglobulin M enzyme-linked immunosorbent assay. For each case, two age- and sex-matched community controls without a history of fever during the preceding month were selected from the same locality. Information on socio-demographic characteristics, agricultural activities, environmental exposures, animal contact, rodent exposure, personal habits and protective practices was collected using a pretested semi-structured questionnaire. Matched odds ratios with 95% confidence intervals were calculated. **Results:** A total of 126 participants, comprising 42 cases and 84 controls, were enrolled. The median age of cases was 33 years, with a range of 1-77 years, and 23 cases (55%) were male. Thirty-two cases (76%) were from rural areas. Fever was present in all cases, followed by generalized weakness in 34 (81%), headache in 27 (64%), nausea or vomiting in 21 (50%) and breathlessness in 21 (50%). Eschar was identified in six cases (14%). Sixteen cases (38%) required hospitalization for 10 days or longer, nine (21%) required mechanical ventilation and three (7%) underwent dialysis. Significant risk factors included having a farm near the residence (matched odds ratio [mOR]: 6.5; 95% confidence interval [CI]: 1.5-28.8), visiting a farm (mOR: 9.0; 95% CI: 2.7-29.7), working in bajra or chari fields (mOR: 5.67; 95% CI: 1.7-19.3), harvesting crops (mOR: 5.67; 95% CI: 1.7-19.3), walking barefoot (mOR: 2.71; 95% CI: 1.1-6.5), walking barefoot on wet surfaces (mOR: 2.86; 95% CI: 1.2-6.8), feeding cattle (mOR: 5.75; 95% CI: 1.9-16.6), entering bushy areas (mOR: 6.25; 95% CI: 2.2-17.9) and sleeping on the ground inside the house (mOR: 21.0; 95% CI: 1.2-358.4). Having a fully cemented floor and bathing after work were protective. **Conclusion:** Agricultural exposure, contact with vegetation, barefoot walking on wet surfaces, cattle-related activities and sleeping on the ground were important risk factors for scrub typhus in Punjab. Community education, use of protective footwear and clothing, avoidance of bushy areas, improved household flooring and personal hygiene after agricultural work should form part of scrub typhus prevention strategies.

Keywords: Scrub typhus; *Orientia tsutsugamushi*; Punjab; case-control study; agricultural exposure; risk factors; chigger mites

INTRODUCTION

Scrub typhus is a zoonotic infectious disease caused by *Orientia tsutsugamushi*, an obligate intracellular bacterium transmitted to humans through the bite of

infected larval trombiculid mites, commonly known as chiggers. The disease is endemic across a large geographical region of Asia and the Pacific. Approximately one million cases are estimated to occur

annually, while nearly one billion people are believed to be at risk of infection.¹

Scrub typhus commonly presents as an acute undifferentiated febrile illness. Its clinical manifestations range from mild fever, headache and generalized weakness to severe multisystem disease. Delayed diagnosis and inappropriate treatment can result in pneumonia, acute respiratory distress syndrome, myocarditis, meningoencephalitis, acute kidney injury, gastrointestinal bleeding, septic shock and multiorgan dysfunction.²⁻⁴ Although the disease responds well to appropriate antimicrobial treatment, its nonspecific presentation, limited diagnostic facilities and inadequate awareness frequently contribute to delayed recognition.

Scrub typhus has long been recognized as endemic in India.⁵ Earlier reports predominantly originated from southern India,⁶⁻⁸ followed by reports from Himalayan regions,⁹⁻¹⁷ the northern plains,¹⁸ coastal regions,¹⁹⁻²³ desert areas²⁴ and metropolitan localities.²⁵ This widening geographical distribution indicates that scrub typhus is no longer restricted to traditionally recognized rural “mite islands.” Changes in land use, urbanization, deforestation, agricultural practices, human movement and vector ecology may have contributed to its emergence in new areas.

Punjab has also witnessed an increasing burden of scrub typhus. According to the Integrated Disease Surveillance Programme, 43, 24 and 88 cases were reported from Punjab during 2015, 2016 and 2017, respectively. A three-year seroprevalence study conducted at a tertiary-care hospital in Punjab between 2012 and 2015 found evidence of scrub typhus in approximately 17% of patients evaluated for fever of unknown origin.²⁶

Humans acquire scrub typhus accidentally when they enter environments inhabited by infected chiggers.^{19,27} Agricultural activities are important sources of exposure in endemic settings. Infections have been associated with rice cultivation in South Korea, Thailand and Japan, and with work in oil palm and rubber plantations in Malaysia.²⁸

Several factors may be contributing to the rising incidence of scrub typhus, including increased outdoor activity among urban populations, rapid urbanization, ageing populations, ecological disturbances, growth of ecotourism, improved diagnostic methods and strengthened surveillance systems.²⁹⁻³¹ Indian studies have reported associations with agricultural work, bushes or shrubs around the home and inadequate protective clothing.^{13,32}

The mites responsible for transmission were previously considered to be primarily restricted to rural scrub vegetation. However, rodents carrying infected mites may facilitate transmission in peri-urban and urban localities. Unplanned urbanization, deforestation, transport-related displacement of rodents and vectors,

poorly maintained kitchen gardens and long grass around homes may create suitable environments for transmission. Urban residents may be exposed during jogging, yoga, gardening, camping or other recreational activities.^{25,33}

Despite the increasing number of reported cases, relatively few Indian studies have systematically investigated the risk factors associated with scrub typhus.^{25,32,34} Hospital-based studies from Punjab have mainly described clinical manifestations and outcomes rather than community-level risk factors.^{2,25,35} Identification of modifiable risk factors is essential for developing context-specific prevention strategies.

Therefore, the present study was conducted to identify the environmental, occupational and behavioural risk factors associated with scrub typhus in five districts of Punjab with relatively high reported incidence.

Objectives

- To identify the risk factors associated with scrub typhus in five districts of Punjab.
- To recommend appropriate measures for the prevention and control of scrub typhus in Punjab.

Hypothesis

Based on preliminary interviews with scrub typhus cases and evidence from previous studies, it was hypothesized that working on farms and walking barefoot on grass or wet surfaces were associated with scrub typhus infection.

Null hypothesis

There is no association between scrub typhus infection and working on farms or walking barefoot on grass.

MATERIALS AND METHODS

Study design

A concurrent 1:2 matched case-control study was conducted.

Study setting

The study was undertaken by the Integrated Disease Surveillance Programme division of the Department of Health, Punjab. Five districts were included: Hoshiarpur, Rupnagar, Shahid Bhagat Singh Nagar, Sahibzada Ajit Singh Nagar and Fatehgarh Sahib. These districts were selected because they had reported scrub typhus incidence rates exceeding one case per 100,000 population during 2017.

Study Period

The study was conducted over six months, from June to November 2018.

Study Population

Residents of the five selected districts constituted the study population.

Case definition

A case was defined as a resident of Hoshiarpur, Rupnagar, Shahid Bhagat Singh Nagar, Sahibzada Ajit Singh Nagar or Fatehgarh Sahib for at least three months who tested positive for scrub typhus by immunoglobulin M enzyme-linked immunosorbent assay between June 1 and November 30, 2018, at the Postgraduate Institute of Medical Education and Research, Chandigarh, or a District Public Health Laboratory in Punjab.

Control Definition

A community control was defined as an age- and sex-matched individual residing in the same village or town as the corresponding case for at least three months and having no history of fever during the month preceding the date of illness onset in the case.

Sample-Size Calculation

The sample size was estimated using an expected exposure prevalence of 42% among controls for agricultural work.¹³ The study was designed to detect an odds ratio of at least 3.0 with 95% confidence and 80% power. The required sample size was 126 participants, comprising 42 cases and 84 controls, with a case-to-control ratio of 1:2.

Selection of Cases

The Department of Medical Microbiology at the Postgraduate Institute of Medical Education and Research, Chandigarh, and District Public Health Laboratories in Punjab reported immunoglobulin M enzyme-linked immunosorbent assay-positive scrub typhus cases to the Integrated Disease Surveillance Programme on a weekly basis. Laboratory registers were reviewed to obtain the contact and residential details of eligible cases. Potential participants were contacted, informed about the study and invited to participate. When a patient could not be contacted by telephone, the local Accredited Social Health Activist or Multipurpose Health Worker assisted in locating the patient using the residential address recorded in the laboratory register. Eligible and consenting cases were interviewed at their residences using a semi-structured questionnaire.

Inclusion Criteria for Cases

1. Meeting the study case definition.
2. Providing written informed consent.
3. Residing in one of the five selected districts for at least three months.

Exclusion Criteria for Cases

1. Refusal to provide informed consent.
2. Inability to trace the individual after two visits made on alternate days.
3. Residence outside the selected study districts.
4. Failure to satisfy the study case definition.

Selection of controls

Two controls were selected for each case from neighbouring households. Investigators initially approached the two immediately adjacent houses on the right side of the case's residence. If suitable controls were unavailable, additional houses in the same direction were approached. When no house was present on the right side, houses on the left, front or rear side were considered sequentially. In isolated areas, the nearest houses along the road were approached. If more than one eligible individual was available in a selected household, one was chosen randomly. For cases residing in multistorey buildings, controls were selected from nearby house or flat numbers.

Matching criteria

- Controls were matched to cases by sex and age group.
- Age-group matching categories used for control selection

Category	Age group
Category 1	0-3 years: preschool age
Category 2	4-17 years: school age
Category 3	18-39 years: adulthood
Category 4	40-59 years: middle age
Category 5	60 years and above: older age

Data Collection Instrument

A pretested semi-structured questionnaire was used. The questionnaire was translated into Punjabi before administration. Information was collected regarding age, sex, education and occupation; type and location of residence; household construction and flooring; clinical history; treatment and hospitalization; laboratory findings; agricultural activities; type of crops and farm work; contact with cattle and other domestic animals; rodent exposure; presence of shrubs or bushes around the house; presence of farms near the house; wood piles and other environmental conditions; barefoot walking; sitting, sleeping or defecating in grass-covered areas; outdoor and recreational activities; bathing and changing clothes after work; and travel history. Exposure history was assessed mainly for the month preceding illness onset, considering the expected incubation period and potential delay between infection and diagnosis.

Environmental Assessment

Investigators directly observed environmental conditions around the participant's residence, including bushes and shrubs, farms near the house, wood piles in the yard, housing construction, household flooring and evidence of rodent infestation. Data collection was undertaken by the principal investigator.

Laboratory Assessment

Available laboratory reports were reviewed for haemoglobin, total leukocyte count, platelet count, serum sodium, serum potassium, serum urea, serum creatinine, aspartate aminotransferase, alanine aminotransferase, total bilirubin and alkaline phosphatase. Repeated laboratory values were recorded when available.

Statistical Analysis

Epi Info was used for questionnaire design, data entry, compilation and analysis. Descriptive analysis was performed for socio-demographic characteristics, clinical manifestations, laboratory findings and hospitalization. Matched bivariate analysis was conducted to calculate matched odds ratios and 95% confidence intervals. An association was considered statistically significant when the 95% confidence interval did not include 1.0.

Ethical Considerations

The protocol was approved by the Research and Institutional Ethics Committee of the National Centre for Disease Control, New Delhi. Written informed consent was obtained from participants aged 18 years or older. For children and adolescents younger than 18 years, consent was obtained from a parent or legal guardian. The study was conducted in accordance with the Declaration of Helsinki and applicable Indian Council of Medical Research ethical guidelines for biomedical research involving human participants. Participants were

informed about the purpose and procedures of the study, their voluntary participation, their right to withdraw at any time, maintenance of confidentiality, protection of personal information and absence of any effect on their medical care if they declined participation. Additional ethical protections were followed for vulnerable participants, including children and pregnant women.

Funding

The study was funded by the India Epidemic Intelligence Service Programme, National Centre for Disease Control, New Delhi.

RESULTS

Recruitment of Participants

A total of 58 scrub typhus cases from the five study districts were reported to the Integrated Disease Surveillance Programme by the Postgraduate Institute of Medical Education and Research, Chandigarh, and District Public Health Laboratories between July and November 2018. Of these, 54 cases were approached. Four reported cases were not approached because two had died and the required sample size had already been achieved before the remaining two could be contacted. Among the cases approached, four were untraceable, three could not be interviewed, two refused participation, two were not residents of the selected districts and one patient had died. A total of 96 controls were approached, of whom 84 consented to participate. The final study population comprised 126 participants: 42 cases and 84 matched controls.

Socio Demographic Characteristics

The median age of cases was 33 years, with a range of 1-77 years. Twenty-three cases (55%) were male. The largest number of cases was reported from Sahibzada Ajit Singh Nagar, followed by Rupnagar.

Table 1. Socio-demographic characteristics of scrub typhus cases, Punjab, June-November 2018

Characteristic	Category	Cases, n	Percentage
Age	Median, range	33 years	1-77 years
Sex	Male	23	55
District	Hoshiarpur	5	12
	Rupnagar	11	26
	Shahid Bhagat Singh Nagar	6	14
	Sahibzada Ajit Singh Nagar	17	40

Characteristic	Category	Cases, n	Percentage
	Fatehgarh Sahib	3	7
Residence	Rural	32	76
House construction	Brick and cement	35	83
	Brick and mud	5	12
	Temporary dwelling/jhuggi	2	5
House flooring	Entire house cemented	25	60
	Cemented only inside rooms	15	36
	Mud flooring	4	10
Living rooms	1-2	16	38
	3-4	22	52
	More than 4	4	10
Family size	1-2 members	4	10
	3-5 members	24	57
	More than 5 members	14	33
Education	Illiterate	6	14
	Primary education	18	43
	More than primary education	18	43
Occupation	Farmer	8	19
	Labourer	3	7
	Homemaker	9	21
	Student	11	26
	Other	11	26
Pregnancy	Pregnant woman	1	2

Thirty-two cases (76%) lived in rural areas. Thirty-five (83%) lived in houses constructed with brick and cement. The most common family size was three to five members. One pregnant woman in her second trimester was included among the cases.

Clinical Manifestations

Fever was present in all cases. Generalized weakness, headache, nausea or vomiting and breathlessness were also frequently reported.

Table 2. Clinical manifestations among scrub typhus cases, Punjab, June-November 2018

Clinical manifestation	Cases, n	Percentage
Fever	42	100
Generalized weakness	34	81
Headache	27	64
Nausea or vomiting	21	50
Breathlessness	21	50
Muscle pain	19	45
Abdominal pain	19	45
Yellow discoloration of sclera	14	33
Cough	9	21
Rash	8	19
Altered sensorium	8	19
Decreased urine output	6	14
Eschar	6	14
Other symptoms	6	14
Loose stools	3	7
Abdominal distension	3	7
Facial swelling	2	5
Leg swelling	2	5

Eschar, which is traditionally considered a characteristic sign of scrub typhus, was identified in only six cases (14%).
Pre-existing medical conditions

Table 3. Medical history among scrub typhus cases

Medical condition	Cases, n	Percentage
Type 2 diabetes mellitus	3	7
Hypertension	3	7
Tuberculosis	1	2
Systemic lupus erythematosus	1	2
Intellectual disability	1	2
Nephrolithiasis	1	2
T-cell lymphoma	1	2
Previous hysterectomy	1	2
Malnutrition	1	2

Type 2 diabetes mellitus and hypertension were the most frequently reported comorbidities.

Hospitalization and severity

Table 4. Duration of hospitalization among scrub typhus cases

Duration of hospitalization	Cases, n	Percentage
Not hospitalized	1	2
1-3 days	0	0
4-6 days	12	29
7-9 days	13	31
10 days or longer	16	38

Sixteen cases (38%) were hospitalized for at least 10 days. Nine cases (21%) required mechanical ventilation and three (7%) required dialysis, indicating that a substantial proportion developed severe illness.

Haematological findings

Table 5A. Complete blood-count findings among scrub typhus cases

Laboratory parameter	Category	First report, n (%)	Second report, n (%)	Third report, n (%)
Haemoglobin	≤5 g/dL	0 (0)	0 (0)	0 (0)
	5.1-8 g/dL	2 (5)	3 (13)	1 (7)
	8.1-11 g/dL	21 (54)	12 (52)	11 (73)
	≥11.1 g/dL	16 (41)	8 (35)	3 (20)
Total leukocyte count	<4,000/μL	3 (8)	1 (4)	1 (7)
	4,000-11,000/μL	16 (41)	11 (48)	9 (64)
	>11,000/μL	20 (51)	11 (48)	4 (29)
Platelets	<150,000/μL	29 (76)	15 (71)	6 (43)
	150,000-450,000/μL	8 (21)	4 (19)	8 (57)
	>450,000/μL	1 (3)	2 (10)	0 (0)

On the first available laboratory assessment, 29 of 38 cases (76%) had thrombocytopenia. Leukocytosis was present in 20 of 39 cases (51%), and 21 of 39 cases (54%) had haemoglobin levels between 8.1 and 11 g/dL.

Electrolyte, renal and liver-function abnormalities

Table 5B. Electrolyte, renal-function and liver-function findings

Laboratory parameter	Category	First report, n (%)	Second report, n (%)	Third report, n (%)
Sodium	<135 mEq/L	22 (61)	9 (45)	7 (47)
	135-145 mEq/L	14 (39)	11 (55)	6 (40)
	>145 mEq/L	0 (0)	0 (0)	2 (13)
Potassium	<3.5 mEq/L	3 (8)	3 (15)	5 (33)
	3.5-5.0 mEq/L	26 (72)	14 (70)	9 (60)
	>5.0 mEq/L	7 (19)	3 (15)	1 (7)
Urea	7-20 mg/dL	7 (18)	2 (10)	3 (20)
	>20 mg/dL	31 (82)	18 (90)	12 (80)
Creatinine	<0.6 mg/dL	11 (29)	7 (35)	5 (33)

Laboratory parameter	Category	First report, n (%)	Second report, n (%)	Third report, n (%)
	0.6-1.2 mg/dL	17 (45)	8 (40)	7 (47)
	>1.2 mg/dL	10 (26)	5 (25)	3 (20)
Aspartate aminotransferase	5-40 IU/L	4 (13)	0 (0)	0 (0)
	>40 IU/L	26 (87)	11 (100)	7 (100)
Alanine aminotransferase	7-56 IU/L	6 (20)	2 (18)	2 (29)
	>56 IU/L	24 (80)	9 (82)	5 (71)
Total bilirubin	0.1-1.2 mg/dL	10 (36)	3 (21)	2 (20)
	>1.2 mg/dL	18 (64)	11 (79)	8 (80)
Alkaline phosphatase	44-147 IU/L	6 (23)	2 (18)	3 (43)
	>147 IU/L	20 (77)	9 (82)	4 (57)

Hyponatraemia was present in 22 of 36 cases (61%) at the first assessment. Serum urea was elevated in 31 of 38 cases (82%), while serum creatinine exceeded 1.2 mg/dL in 10 of 38 cases (26%). Liver-function abnormalities were common. Aspartate aminotransferase was elevated in 26 of 30 cases (87%), alanine aminotransferase was elevated in 24 of 30 cases (80%), total bilirubin was elevated in 18 of 28 cases (64%) and alkaline phosphatase was elevated in 20 of 26 cases (77%).

Socio Demographic Risk Factors

Table 6A. Association between socio-demographic factors and scrub typhus

Exposure	All exposed	All unexposed	Case exposed	Case unexposed	mOR	95% CI
Rural residence	64	20	0	0	Not estimable	-
Brick-and-cement house	68	2	2	12	0.17	0.0-0.7
Entire house cemented	46	16	4	18	0.22	0.1-0.7
Overcrowding	25	27	20	12	1.67	0.8-3.4
Education up to primary level	39	17	9	19	0.47	0.2-1.1
Farmer or labourer	14	59	8	3	2.7	0.7-10.1

Living in a house with fully cemented flooring was significantly protective against scrub typhus.

Environmental Risk Factors

Table 6B. Association between household environmental factors and scrub typhus

Exposure	All exposed	All unexposed	Case exposed	Case unexposed	mOR	95% CI
Bushes or shrubs around the house	19	47	13	5	2.6	0.9-7.2
Farm near the house	17	52	13	2	6.5	1.5-28.8
Wood piles in the yard	16	40	19	9	2.1	0.9-4.7

Participants living near farms had approximately 6.5 times the odds of scrub typhus compared with participants without a farm near their residence. Bushes or shrubs around the house and piles of wood were associated with increased odds, although their confidence intervals included unity.

Agricultural, Behavioural and Animal Related Exposures

Table 6C. Association between agricultural, behavioural and protective factors and scrub typhus

Exposure	All exposed	All unexposed	Case exposed	Case unexposed	mOR	95% CI
Visited a farm	19	35	27	3	9.00	2.7-29.7
Worked on a farm	18	53	10	3	3.33	0.9-12.1
Worked in a rice field	2	70	4	8	0.06	0.0-0.2
Worked in a corn field	4	76	4	0	9.00	0.5-167.2
Worked in bajra or chari field	4	60	17	3	5.67	1.7-19.3
Harvesting	4	60	17	3	5.67	1.7-19.3
Walked barefoot	7	51	19	7	2.71	1.1-6.5
Walked barefoot on dry surface	4	62	10	8	1.25	0.5-3.2
Walked barefoot on wet surface	2	55	20	7	2.86	1.2-6.8
Sat on grass	1	66	12	5	2.4	0.8-6.8
Napped on grass	0	80	4	0	9.0	0.5-167.2
Defecated in a grass-covered field	1	76	7	0	15.0	0.9-262.7
Fed cattle	7	50	23	4	5.75	1.9-16.6
Entered bushy areas	5	50	25	4	6.25	2.2-17.9
Rodents present at home	48	16	14	6	2.33	0.9-6.1
Rodents present at workplace	44	19	12	9	1.33	0.6-3.2
Slept on the ground inside house	0	74	10	0	21.0	1.2-358.4
Bathed after work	65	6	1	12	0.08	0.0-0.6
Bathed within seven days after work	9	52	7	16	0.44	0.2-1.1
Changed clothes before sleeping	65	10	1	8	0.13	0.0-1.0
Changed clothes within seven days	20	40	8	16	0.50	0.2-1.2

The strongest identified risk factors were sleeping on the ground inside the house and visiting a farm. However, the estimate for sleeping on the ground had a wide confidence interval because of the small number of exposed participants. Bathing after work was strongly protective. Changing clothes before sleeping also appeared protective, although the upper confidence limit approached 1.0.

DISCUSSION

Overview of Principal Findings

The present community-based matched case-control study identified several important environmental, agricultural and behavioural risk factors for scrub typhus in Punjab. Visiting farms, working in bajra or chari fields, harvesting crops, walking barefoot, walking barefoot on wet surfaces, feeding cattle, entering bushy areas and sleeping on the ground were significantly associated with infection. In contrast, having fully cemented household flooring and bathing after work were protective. These findings support the hypothesis that agricultural and vegetation-related exposures are central to scrub typhus transmission in Punjab. The

findings also demonstrate that risk is determined not merely by an individual's occupation but by specific activities and environmental contacts.

Socio-Demographic and Residential Characteristics

Most cases were residents of rural areas, reflecting the close relationship between scrub typhus and environments that support chigger mites and rodent hosts. Rural residence could not be evaluated as an independent risk factor because the matched case-control sets were largely concordant for this exposure. Occupation as a farmer or labourer was associated with increased odds of scrub typhus, although the association was not statistically significant. This may be because

individuals who were not formally classified as farmers nevertheless entered farms, participated in harvesting, fed cattle or engaged in other agricultural activities. The study therefore suggests that actual exposure-related behaviours may be more informative than occupational labels. Fully cemented household flooring was significantly protective. Cemented floors may reduce human contact with soil, mites and rodents inside the household. Conversely, mud floors and cracks in poorly maintained flooring may provide favourable conditions for rodents and mite vectors. Improving flooring may therefore have broader health benefits in addition to reducing scrub typhus exposure.

Environmental Exposure around the Residence

Having a farm near the house was an important environmental risk factor. Individuals with farms close to their homes may be exposed while walking through fields, performing routine household activities, collecting fodder, tending animals or allowing children to play near agricultural land. Bushes or shrubs around the house were associated with increased odds, although the association did not reach conventional statistical significance. Similar environmental associations have been reported from Darjeeling and southern India.^{13,32} Scrub vegetation provides favourable conditions for rodents and trombiculid mites and may create small, localized areas of intense transmission. Wood piles in the yard also showed a positive association. Wood piles can provide shelter for rodents and may maintain humid microenvironments favourable for mites. Although the confidence interval included unity, environmental management around houses should include removal or proper storage of wood, clearing of unnecessary vegetation and control of rodent habitats.

Agricultural Exposure

Visiting a farm was associated with nine times the odds of scrub typhus. This was among the strongest and most precise associations identified in the study. Agricultural land may support rodents, mites, grasses and scrub vegetation that facilitate transmission. Working on a farm had a positive but statistically nonsignificant association. The smaller effect compared with merely visiting a farm may reflect differences in the definition of exposure or variation in protective practices among regular agricultural workers. Individuals who routinely work on farms may use footwear, change clothes or bathe after work more consistently than occasional visitors. Crop-specific analysis indicated that working in bajra or chari fields was associated with significantly increased risk. Bajra and chari crops may create dense vegetation and moist shaded areas favourable for rodent and mite survival. Harvesting was similarly associated with increased risk, probably because workers come into

direct contact with crops, soil and lower vegetation. Agricultural exposure has been recognized as an important determinant of scrub typhus in several endemic countries.²⁸ Studies from India have similarly associated infection with agricultural work, vegetation and outdoor exposure.^{13,32,34} The apparent protective association with rice-field work should be interpreted cautiously. It may have resulted from a small number of exposed participants, differences in agricultural practices or incomplete characterization of the duration and intensity of exposure.

Barefoot Walking and Contact with Wet Surfaces

Walking barefoot was associated with approximately 2.7 times the odds of scrub typhus. The risk was particularly evident when participants walked barefoot on wet surfaces. Wet soil and grass may support mite survival and increase the likelihood of contact between chiggers and exposed skin. Barefoot walking may also expose the ankles and lower legs, which are common sites for chigger attachment. In contrast, barefoot walking on dry surfaces was not significantly associated with infection. This difference suggests that the environmental characteristics of the walking surface may influence transmission risk. The findings support the promotion of closed footwear, boots or other protective footwear during agricultural work, particularly in wet fields or areas with dense vegetation.

Contact with Bushes and Grass

Entering bushy areas was associated with more than six times the odds of infection. Bushes and scrub vegetation are well-recognized habitats for mites and rodent hosts. The finding is consistent with previous Indian studies that have associated scrub typhus with vegetation around residences and outdoor occupational exposure.^{13,32} Sitting, napping or defecating in grass-covered fields also showed elevated odds, although some associations were imprecise because of the small number of exposed individuals. These activities increase the duration of contact between exposed skin, clothing and mite-infested vegetation. Community education should therefore discourage unnecessary sitting, sleeping or resting directly on grass or soil in endemic settings. Mats or raised surfaces should be used when resting outdoors.

Animal and Rodent Exposure

Feeding cattle was associated with almost six times the odds of scrub typhus. Cattle do not directly transmit *O. tsutsugamushi* to humans; however, cattle-related activities may place individuals in barns, fodder-storage areas, fields and other environments inhabited by rodents and mites. Fodder collection and handling may also involve contact with grasses and vegetation where chiggers are present. Animal sheds may provide food

and shelter for rodents, indirectly increasing the risk of mite exposure. Rodents at home showed a positive but statistically nonsignificant association. Rodents are important hosts in the maintenance of trombiculid mite populations. The absence of statistical significance may reflect the high prevalence of rodents in both case and control households, reducing the ability to distinguish their effects. Rodent-control interventions should be combined with environmental sanitation, secure food storage, removal of waste, clearing of vegetation and reduction of potential nesting sites.

Sleeping on the Ground

Sleeping on the ground inside the house showed the highest matched odds ratio in the study. Ground sleeping may result in prolonged exposure to mites transported into the household by rodents or domestic animals. It may also increase contact with soil, dust and floor-level arthropods. However, the confidence interval was extremely wide, indicating statistical imprecision. Only a small number of participants reported this practice. Therefore, the magnitude of the association should be interpreted cautiously. Nevertheless, the direction and biological plausibility of the association support the recommendation that individuals use raised beds, cots or sleeping platforms rather than sleeping directly on the ground.

Protective Effect of Bathing and Changing Clothes

Bathing after work was strongly protective. Bathing may remove unattached mites from the skin before they feed or reduce the duration of exposure. Washing exposed body parts after returning from farms or bushy areas may therefore be an inexpensive and practical preventive measure. Changing clothes before sleeping also appeared protective. Clothes used in fields may carry mites into the household. Prompt removal and washing of work clothing may prevent prolonged exposure and reduce the risk of transferring mites to bedding or other family members. The findings are consistent with the concept that simple behavioural interventions can reduce scrub typhus risk. Sharma et al. similarly highlighted opportunities for practical preventive measures in endemic communities.¹³

Clinical Manifestations

All cases presented with fever, emphasizing that scrub typhus should be considered in the differential diagnosis of acute febrile illness in Punjab, especially during seasonal periods of increased transmission. Generalized weakness, headache, gastrointestinal symptoms, breathlessness, muscle pain and abdominal pain were common. These manifestations are nonspecific and overlap with dengue, malaria, leptospirosis, enteric fever and other tropical infections. Eschar was detected in only

14% of cases. Although an eschar can provide an important diagnostic clue, its absence should not be used to exclude scrub typhus. Eschars may be small, painless or located in concealed anatomical areas. Their detection may also be influenced by skin pigmentation, clinical awareness and the thoroughness of physical examination. Yellow sclera, altered sensorium, decreased urine output and respiratory symptoms indicated multisystem involvement in several cases.

Disease Severity and Hospitalization

A substantial proportion of cases experienced severe disease. More than one-third were hospitalized for at least 10 days, approximately one-fifth required mechanical ventilation and 7% underwent dialysis. These findings demonstrate the potential of scrub typhus to cause prolonged hospitalization, respiratory failure and renal dysfunction. Previous reports from Punjab and other regions have similarly described multisystem involvement and severe clinical outcomes.^{2,35} Early clinical suspicion and timely initiation of effective antimicrobial therapy are therefore essential. Diagnostic testing should be made available at facilities evaluating patients with acute undifferentiated fever.

Laboratory Abnormalities

Thrombocytopenia was present in more than three-fourths of cases with available initial platelet counts. Leukocytosis, anaemia, hyponatraemia, elevated serum urea and abnormal liver-function tests were also common. Elevated aspartate aminotransferase, alanine aminotransferase, bilirubin and alkaline phosphatase indicate frequent hepatic involvement. Elevated urea and creatinine and the requirement for dialysis in some patients demonstrate renal involvement. These abnormalities are not specific to scrub typhus but may support the clinical diagnosis when considered together with epidemiological exposure and compatible febrile illness.

Public Health Implications

The findings have several implications for scrub typhus prevention and control in Punjab. First, health education should be directed not only towards farmers but also towards students, homemakers, labourers and other residents who occasionally enter agricultural fields. Second, prevention messages should focus on specific activities, including avoiding walking barefoot in fields and wet grass, using boots or closed footwear during farm work, wearing clothing that covers the legs and arms, avoiding unnecessary bushy or densely vegetated areas, avoiding sitting or sleeping directly on grass or soil, bathing promptly after agricultural work, changing and washing work clothes before sleeping, maintaining clean household surroundings, removing unnecessary

bushes, long grass and wood piles, reducing rodent access to houses and animal sheds and using raised sleeping arrangements. Third, healthcare workers should be trained to consider scrub typhus in patients with acute fever, thrombocytopenia, elevated liver enzymes, renal abnormalities or exposure to farms and vegetation. Fourth, surveillance should be strengthened to identify seasonal and geographical clusters and to provide early warnings to affected communities.

Strengths of the Study

The study used laboratory-confirmed cases, selected community controls from the same locality, matched controls by age and sex, directly observed environmental conditions around the residence, collected detailed crop-specific and activity-specific exposure information and identified practical, modifiable risk factors suitable for public-health intervention.

Limitations

The findings should be interpreted in light of certain limitations. First, the sample size was relatively small, resulting in wide confidence intervals for uncommon exposures such as sleeping on the ground, napping on grass and defecating in fields. Second, exposure information was self-reported and may have been affected by recall bias. Third, cases were identified through selected laboratories and surveillance reporting. Patients who were not tested, were treated empirically or had limited access to healthcare may not have been included. Fourth, neighbourhood controls may have shared many environmental exposures with cases. This could have reduced the apparent magnitude of associations for factors such as rural residence, rodent exposure and vegetation around houses. Fifth, the analysis was primarily bivariate. Potential confounding among correlated exposures such as farming, harvesting, cattle feeding, bushes and barefoot walking could not be fully assessed. Finally, laboratory investigations were not uniformly available for all cases or at standardized intervals.

CONCLUSION

Scrub typhus is an important emerging public-health problem in Punjab and can cause severe multisystem disease requiring prolonged hospitalization, mechanical ventilation and dialysis. The study identified several important risk factors, including visiting agricultural fields, working in bajra or chari fields, harvesting crops, walking barefoot, walking barefoot on wet surfaces, feeding cattle, entering bushy areas, living near agricultural fields and sleeping directly on the ground. Having a fully cemented household floor and bathing after work were protective. Preventive efforts should focus on reducing contact with mite-infested

environments through protective footwear and clothing, environmental management, improved household flooring, rodent control, safe agricultural practices and personal hygiene after outdoor work.

Recommendations

- Individuals should wear closed footwear or boots while working in agricultural fields, particularly in wet fields.
- Walking barefoot on wet soil, grass or agricultural land should be avoided.
- Full-sleeved clothing and garments covering the lower limbs should be used during farming, harvesting and fodder collection.
- Individuals should avoid unnecessary entry into bushy or densely vegetated areas.
- Hands and exposed body parts should be washed after agricultural work, harvesting and feeding cattle.
- Individuals should bathe as soon as possible after returning from farms or bushy areas.
- Clothes worn during agricultural work should be changed and washed before sleeping.
- Sitting, lying, napping or sleeping directly on grass or soil should be avoided.
- Raised cots or beds should be used instead of sleeping directly on household floors.
- Bushes, long grass and unnecessary vegetation should be cleared from around residences.
- Wood piles should be properly stored away from living areas.
- Measures should be undertaken to reduce rodent infestation in houses, farms and cattle sheds.
- Household floors should be cemented wherever feasible.
- Farmers and rural residents should be educated regarding the symptoms and risk factors of scrub typhus.
- Healthcare workers should consider scrub typhus in patients with acute febrile illness and relevant agricultural or environmental exposure.
- Scrub typhus surveillance should be strengthened in districts reporting increasing numbers of cases.
- Diagnostic facilities and referral pathways should be strengthened to ensure early diagnosis and timely treatment.

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Ethical Approval

The study protocol was approved by the Research and Institutional Ethics Committee of the National Centre for Disease Control, New Delhi. Written informed consent was obtained from adult participants and from parents or legal guardians of participants younger than 18 years.

Informed Consent

Written informed consent was obtained from all eligible adult participants. For children and adolescents, written consent was obtained from a parent or legal guardian.

Conflict of Interest

None.

Data Availability

The data supporting the findings of the study may be made available by the corresponding author in accordance with applicable institutional and ethical requirements.

Abbreviations

- CI – Confidence Interval
- ELISA – Enzyme-Linked Immunosorbent Assay
- IDSP – Integrated Disease Surveillance Programme
- ICMR – Indian Council of Medical Research
- mOR – Matched Odds Ratio
- NCDC – National Centre for Disease Control
- PGIMER – Postgraduate Institute of Medical Education and Research
- *O. tsutsugamushi* – *Orientia tsutsugamushi*

REFERENCES

1. Xu G, Walker DH, Jupiter D, Melby PC, Arcari CM. A review of the global epidemiology of scrub typhus. *PLoS Negl Trop Dis*. 2017;11(11).
2. Chogle AR. Diagnosis and treatment of scrub typhus: the Indian scenario. *J Assoc Physicians India*. 2010;58:11-12.
3. Matthew AJ, George J. Acute kidney injury in the tropics. *Ann Saudi Med*. 2011;31:451-456.
4. Oberoi A, Varghese SR. Scrub typhus: an emerging entity-a study from a tertiary care hospital in North India. *Indian J Public Health*. 2014;58:281-283.
5. Padbidri VS, Gupta NP. Rickettsiosis in India: a review. *J Indian Med Assoc*. 1978;71(4):104-107.
6. Mathai E, Rolain JM, Varghese GM, Abraham OC, Mathai D, Mathai M, et al. Outbreak of scrub typhus in southern India during the cooler months. *Ann N Y Acad Sci*. 2003;990:359-364.
7. Isaac R, Varghese GM, Mathai E, Manjula J, Joseph I. Scrub typhus: prevalence and diagnostic issues in rural southern India. *Clin Infect Dis*. 2004;39(9):1395-1396.
8. Usha K, Kumar E, Kalawat U, Kumar BS, Chaudhury A, Sai Gopal DVR. Seroprevalence of scrub typhus among febrile patients: a preliminary study. *Asian J Pharm Clin Res*. 2014;7(1):19-21.
9. Kumar K, Saxena VK, Thomas TG. Outbreak investigation of scrub typhus in Himachal Pradesh. *J Commun Dis*. 2004;36(4):277-283.
10. Sharma A, Mahajan S, Gupta ML, Kanga A, Sharma V. Investigation of an outbreak of scrub typhus in the Himalayan region of India. *Jpn J Infect Dis*. 2005;58(4):208-210.
11. Mahajan SK. Scrub typhus. *J Assoc Physicians India*. 2005;53:954-958.
12. Mahajan SK, Rolain JM, Sankhyani N, Kaushal RK, Raoult D. Pediatric scrub typhus in the Indian Himalayas. *Indian J Pediatr*. 2008;75:947-949.
13. Sharma PK, Ramakrishnan R, Hutin YJ, Barui AK, Manickam P, Kakkar M, et al. Scrub typhus in Darjeeling, India: opportunities for simple, practical prevention measures. *Trans R Soc Trop Med Hyg*. 2009;103(11):1153-1158.
14. Kumar D, Raina DJ, Gupta S, Angurana A. Epidemiology of scrub typhus. *JK Sci*. 2010;12(2):60-62.
15. Digra SK, Saini GS, Singh V, Sharma SD, Kaul R. Scrub typhus in children: Jammu experience. *JK Sci*. 2010;12(2):95-97.
16. Ahmad S, Srivastava S, Verma SK, Puri P, Shirazi N. Scrub typhus in Uttarakhand, India: a common rickettsial disease in an uncommon geographical region. *Trop Doct*. 2010;40:188-190.
17. Mahajan SK, Rolain JM, Kashyap R, Bakshi D, Sharma V, Prasher BS, et al. Scrub typhus in the Himalayas. *Emerg Infect Dis*. 2006;12:1590-1592.
18. Chaudhry D, Garg A, Singh I, Tandon C, Saini R. Rickettsial diseases in Haryana: not an uncommon entity. *J Assoc Physicians India*. 2009;57:334-337.
19. Paris DH, Day NPJ. Tropical rickettsial infections. In: *Manson's Tropical Infectious Diseases*. 23rd ed. London: WB Saunders; 2014. p. 273-291.
20. Narvencar KP, Rodrigues S, Nevrekar RP, Dias L, Dias A, Vaz M, et al. Scrub typhus in patients presenting with acute febrile illness at a tertiary healthcare institution in Goa. *Indian J Med Res*. 2012;136:1020-1024.

21. Ittyachen AM. Emerging infections in Kerala: a case of scrub typhus. *Natl Med J India*. 2009;22(6):33-34.
22. Saifudheen K, Kumar KGS, Jose J, Veena V, Gafoor VA. First case of scrub typhus with meningoencephalitis from Kerala: an emerging infectious threat. *Ann Indian Acad Neurol*. 2012;15(2):141-144.
23. Sharma AK, Kumar K. Entomological surveillance for rodents and their ectoparasites with special reference to the potential for scrub typhus at Kolkata Port Trust, Kolkata, India. *J Paramed Sci*. 2014;5(2):2-6.
24. Sharma R, Krishna VP, Manjunath, Singh H, Shrivastava S, Singh V, et al. Analysis of two outbreaks of scrub typhus in Rajasthan: a clinico-epidemiological study. *J Assoc Physicians India*. 2014;62:24-29.
25. Mittal V, Gupta N, Bhattacharya D, Kumar K, Ichhpujani RL, Singh S, et al. Serological evidence of rickettsial infections in Delhi. *Indian J Med Res*. 2012;135:538-541.
26. Thomas M, Oberoi A, Alexander VS, Mani A. Serological evidence of rickettsial infections in a tertiary-care centre in Punjab. *Int J Basic Appl Med Sci*. 2016;6(2):114-117.
27. Vivekanandan M, Mani A, Priya YS, Singh AP, Jayakumar S, Purty S. Outbreak of scrub typhus in Pondicherry. *J Assoc Physicians India*. 2010;58:24-28.
28. Lyu Y, Tian L, Zhang L, Dou X, Wang X, et al. A case-control study of risk factors associated with scrub typhus infection in Beijing, China. *PLoS One*. 2013;8(5):e63668.
29. Strickman D, Tanskul P, Eamsila C, Kelly DJ. Prevalence of antibodies to rickettsiae in the human population of suburban Bangkok. *Am J Trop Med Hyg*. 1994;51:149-153.
30. Matsui T, Kramer MH, Mendlein JM, Osaka K, Ohyama T, et al. Evaluation of national tsutsugamushi disease surveillance, Japan, 2000. *Jpn J Infect Dis*. 2002;55:197-203.
31. Lee YS, Wang PH, Tseng SJ, Ko CF, Teng HJ. Epidemiology of scrub typhus in eastern Taiwan, 2000-2004. *Jpn J Infect Dis*. 2006;59:235-238.
32. Varghese GM, Rai D, Francis MR, Sarkar R, Trowbridge P, Muliylil J. Epidemiology and risk factors of scrub typhus in southern India. *Indian J Med Res*. 2016;144(1):76-81.
33. Laskar AR, Suri S, Acharya AS. Scrub typhus: a re-emerging public-health problem in India. *J Commun Dis*. 2015;47(3):19-25.
34. Trowbridge P, Divya P, Premkumar PS, Varghese GM. Prevalence and risk factors for scrub typhus in southern India. *Trop Med Int Health*. 2017;22(5):576-582.
35. Loomba V, Mani A, John M. Scrub typhus in Punjab: an acute febrile illness with multisystem involvement. *Trop Doct*. 2014;44(3):152-155.