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Spatial Spread of Respiratory Diseases in Dust-Prone Zones of Rajasthan: A Medical Geographical Study

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Abstract: ***Dust-prone zones of Rajasthan, particularly the districts of Bikaner, Churu, Jhunjhunu, Jaisalmer, and parts of Nagaur, face a disproportionately high burden of respiratory diseases due to arid climatic conditions, sandy soils, frequent dust storms, and anthropogenic dust generated from unpaved roads and agriculture. This study investigates the incidence, spatial patterns, and determinants of respiratory diseases using medical geographical methods. The research integrates district-level health records, environmental data, to examine the distribution of diseases such as asthma, chronic obstructive pulmonary disease, bronchitis, tuberculosis, and acute respiratory infections. The analysis reveals a strong correlation between dust storm frequency, particulate matter levels, and respiratory morbidity. The study also finds that rural habitations located near open fields, sand dunes, and degraded grazing lands exhibit higher disease incidence. Spatial patterns show clustering of cases in northern and western Rajasthan. The research concludes that respiratory diseases in dust-prone regions are primarily influenced by climatic aridity, soil instability, land degradation, and lack of preventive health infrastructure. Recommendations focus on dust mitigation, environmental rehabilitation, and improved public health strategies.***

Keywords: Respiratory diseases; dust-prone zones; Rajasthan; medical geography; spatial epidemiology; dust storms; asthma.

1.1 Introduction

Rajasthan's desert and semi-desert regions are globally known for their extensive sandy terrain, low vegetation cover, and recurring dust storms that significantly degrade air quality. These environmental conditions make respiratory diseases a major public health concern. According to the National Health Profile (2017), Rajasthan consistently ranks high in the incidence of asthma, COPD, and ARIs, particularly in districts exposed to dust and wind erosion. Dust-prone regions like Bikaner, Churu, and Jaisalmer experience over 20–30 dust storms annually.

Medical geography provides a comprehensive framework for studying the interaction between environment and disease. Respiratory diseases serve as a classic example where spatial factors—climate, soil, vegetation, and human activities—directly influence prevalence. Previous studies (Mehta, 2015; Ghosh, 2012) have highlighted the significance of desert environments in disease ecology, yet detailed spatial analysis on respiratory diseases in Rajasthan remains limited.

This research addresses this gap by analysing the incidence and spatial spread of respiratory diseases in dust-prone zones of Rajasthan, integrating environmental and health datasets. The study emphasises the influence of dust storms, particulate matter, and land degradation on disease incidence and identifies high-risk zones for targeted interventions.

1.2 Objectives

1. To map the spatial distribution of respiratory diseases—asthma, bronchitis, Tuberculosis, and ARIs—in dust-prone districts of Rajasthan.
2. To analyse the relationship between dust intensity, particulate matter concentration, and respiratory morbidity.
3. To identify spatial disease clusters and high-risk zones.
4. To examine environmental and socio-economic determinants influencing disease spread.
5. To recommend public health strategies for disease prevention and mitigation.

1.3 Methodology

I. Study Design

A spatial epidemiological and descriptive research design is used to capture disease distribution patterns.

II. Data Sources

1. District-level morbidity data: Directorate of Medical and Health Services, Rajasthan (2014–2017).
2. Tuberculosis case data: Revised National Tuberculosis Control Programme (2016).
3. Environmental data: IMD, Desert Meteorology Centre, Jodhpur (dust storm frequency; PM10/PM2.5 levels).
4. Land use/land cover (2011).

III. Analytical Techniques

1. Spatial mapping of disease incidence.
2. Hotspot detection using Moran's I and Getis-Ord Gi* statistics.

3. Correlation analysis between disease incidence and environmental indicators.

4. Buffering around dust hotspots (sand dunes, barren land, unpaved roads).

5. Comparative district-wise assessment.

1.4 Study Area

Rajasthan, the largest state of India situated in the north-western part of the Indian union is largely and arid state for most of its part. The Tropic of Cancer passes through south of Banswara town. Presenting an irregular rhomboid shape, the state has a maximum length of 869 km. from west to east and 826 km. from north to south. The western boundary of the state is part of the Indo-Pak international boundary, running to an extent of 1,070 km. It touches four main districts of the region, namely, Barmer, Jaisalmer, Bikaner and Ganganagar. The state is girdled by Punjab and Haryana states in the north, Uttar Pradesh in the east, Madhya Pradesh in south east and Gujarat in the south west.

Rajasthan which consisted of 19 princely states, the centrally administered province of Ajmer-Merwara, and 3 principalities in the times of the British rule, was formerly known as Rajputana-the land of Rajputs, whose chivalry and heroism has been celebrated in the legendary tales from times immemorial. The. formation of Rajasthan state in its present form started in 1948 when the states Reorganization Commission reconstited the various provinces.

It was on 18th March 1948, that the feudal states of Alwar, Bharatpur, Dhaulpur and Karauli were merged to form the "Matsya Union", the confederation having its capital at Alwar. Only about a week later, on 25th March 1948, other ten states viz. Banswara, Bundi, Dungarpur, Kishangarh, Kushalgarh, Kota, Jhalawar, Pratapgarh, Shahpura and Tonk formed another union of states called "Eastern Rajasthan" with its separate capital at Kota. On the April 18th 1948, Udaipur state also joined this federation which was renamed as Union of Rajasthan. About a year later, on March 30th 1949, the other major states of Rajputana viz. Bikaner, Jaipur, Jodhpur and Jaisalmer also joined the federation. The Matsya Union was also merged with the larger federation and the combined political complex, under the name of Greater Rajasthan, came into existence with Jaipur as the capital. On January 26th 1950, Sirohi state too joined this federation which was thereafter named as Rajasthan. The centrally administefred area of Ajmer Merwara was merged with Rajasthan on November 1 th 1956, when the recommendations of the State Reorganization Commission were accepted, and the new state of India came into existence.

The rich wealth of non-renewable resources is yet to be explored and exploited. Their judicious exploitation can make the state economically self-sufficient. At the same time, renewable resources like solar power, wind and water can also be harnessed effectively to serve man's needs.

The study focuses on Rajasthan’s most dust-prone districts, identified on the basis of climatic aridity and dust storm activity:

1. Bikaner, 2. Churu, 3. Nagaur (western belt), 4. Jhunjhunu (northern belt) and 5. Jaisalmer

Environmental Characteristics:

1. Climate: Extremely arid to semi-arid; rainfall <200–350 mm/year.

2. Soil: Loose aeolian sand, high erodibility.

3. Vegetation: Sparse xerophytic shrubs, degraded grazing lands.

4. Wind regime: High velocity winds (20–40 km/h) causing frequent dust storms (April–July).

5. Human factors: Overgrazing, shifting sands, unpaved roads, brick kilns.

These characteristics create a natural dust corridor with chronic exposure to airborne particulate matter.

1.5 Observations

I. District-Wise Incidence (per 10,000 population)

1. Asthma: Highest in Churu (67) and Bikaner (62).

2. COPD: Highest in Jaisalmer (74).

3. Bronchitis: Nagaur and Jhunjhunu show moderate burden (40–55).

4. ARI: Highest in children in Bikaner and Churu.

5. Tuberculosis: Nagaur shows higher Tuberculosis incidence linked with dust-induced respiratory vulnerability.

II. Environmental Observations

1. Villages near sand dunes show 40–60% higher respiratory disease incidence.

2. PM10 levels exceed 200–300 µg/m³ during peak summer dust events.

3. Unpaved roads significantly increase localised dust emissions.

4. Overgrazed and barren lands correlate with disease hotspots.

III. Spatial Patterns

1. Disease hotspots concentrated in Bikaner’s Lunkaransar–Kolayat belt, Churu’s Taranagar–Sardarshahar belt, and Jaisalmer’s Pokhran.

2. Cold spots (low-risk areas) include irrigated zones of Indira Gandhi Canal.

1.6 Discussion

The spatial distribution of respiratory diseases strongly reflects environmental determinants. Dust-prone regions of Rajasthan exhibit unique ecological stressors:

1. Impact of Dust Storms

Dust storms carry fine particulate matter deep into the respiratory tract, aggravating and asthma. The Desert Meteorology Centre identifies Bikaner–Churu belt as the core dust corridor, explaining high disease clustering.

2. Soil and Land Degradation

Loose sandy soils amplify wind erosion. Overgrazing and shrinking vegetative cover increase dust mobility, creating persistent exposure zones.

3. Socio-Economic Factors

Low-income rural households use biomass fuel, lack protective gear, and delay seeking medical care, further increasing disease severity.

4. Irrigation as a Protective Factor

Indira Gandhi Canal–irrigated areas (Sri Ganganagar–Hanumangarh) show reduced dust and disease incidence, demonstrating a clear land–health linkage.

5. TB and Dust Exposure

Dust damages lung tissues and weakens immunity, increasing vulnerability to Tuberculosis, particularly in Nagaur and Jaisalmer.

1.7 Results

1. Respiratory diseases exhibit strong spatial clustering in dust-prone regions.
2. Highest incidence observed in Churu, Bikaner, and Jaisalmer districts.
3. Environmental indicators—dust storm frequency, PM10 levels, bare soil area—strongly correlate with disease burden (r = 0.62 to 0.78).
4. Hotspot analysis identifies 23 high-risk clusters.
5. Dust suppression, land rehabilitation, and improved rural health surveillance are urgently required.

1.8 Conclusion

Respiratory diseases in Rajasthan's dust-prone zones are heavily influenced by environmental factors. The study demonstrates that climatic aridity, frequent dust storms, soil instability, and human-induced degradation collectively create a high-risk ecological environment. assessment provides a clear visualisation of disease hotspots, enabling precise identification of vulnerable populations. Strengthening environmental management and rural healthcare services is essential for reducing respiratory morbidity in these regions.

1.9 Recommendations

I. Dust-Reduction Measures

1. Stabilisation of sand dunes using vegetation and fencing.
2. Plantation of xerophytic species (e.g., Acacia senegal, Prosopis cineraria).
3. Paving of rural roads.

II. Public Health Actions

1. Establish respiratory care units in Bikaner and Churu.
2. Seasonal surveillance during dust storm months.
3. Free distribution of masks in high-risk zones.

III. Environmental Monitoring

1. Install PM10 monitoring stations in rural pockets.
2. Dust and disease monitoring units at district level.

IV. Health Education

1. Awareness on indoor pollution, biomass smoke, and dust inhalation risks.

V. Medical Infrastructure

1. Mobile respiratory clinics in remote villages.
2. Improved diagnostic facilities for asthma and Tuberculosis.

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