Altitude-Related Illness and Its Management During a High-Altitude Medical Camp in Adi Kailash, Uttarakhand

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***Abstract*—Background: Acute Mountain Sickness (AMS) and related altitude-related illness are common but poorly documented health risks in high-altitude pilgrimage and border regions of the Indian Himalayas, where medical infrastructure is limited and terrain is remote. This paper describes how altitude-related illness presented clinically and was managed on-site during a 20-day medical camp held at Adi Kailash (~14,700 ft) in Pithoragarh district, Uttarakhand.**

Methods: A retrospective review was conducted on a randomly selected sample of 300 patient records out of roughly 1,300 individuals treated during the camp (May-June). Patients were classified as having altitude-related illness using a case definition spanning three presentation types: an explicit clinical diagnosis of AMS, an AMS-compatible presentation (headache with an associated symptom - nausea, vomiting, dizziness, fatigue, or dyspnea), or a hypoxemic/respiratory presentation (documented SpO2 ≤80% with headache and tachypnea). Patients within the hypoxemic/respiratory group who also had documented disorientation were additionally flagged as showing a neurological red flag consistent with possible severe altitude-related illness. Demographic characteristics, presentation category, and management outcomes were extracted and analyzed.

Results: Of 300 sampled patients, 49 (16.3%) met the study's criteria for altitude-related illness. Of these, 32 (65.3%) had a hypoxemic/respiratory presentation (SpO2 ≤80%, headache, tachypnea); a subset of this group also showed disorientation, a neurological red flag raising concern for possible severe altitude-related illness such as high-altitude cerebral edema (HACE), though this subgroup was not separately quantified in camp records. The remaining patients had either an explicit AMS diagnosis (11, 22.4%) or an AMS-compatible presentation of headache plus an associated symptom (6, 12.2%). Cases were predominantly male (75.5%) and among tourists/pilgrims rather than local residents (91.8% vs 8.2%). Mean age was 37.8 years (range 3-71). All 49 patients, including those with hypoxemic/respiratory presentations, were managed entirely on-site; none required referral to the nearest ITBP medical post (~40 km away).

Conclusion: Altitude-related illness represented a substantial share of morbidity at this high-altitude camp and disproportionately affected non-acclimatized visitors. Despite resource constraints such as cold-affected equipment and the absence of backup power, the camp team managed even hypoxemic/respiratory presentations without needing evacuation, indicating that adequately staffed field camps can deliver competent frontline management of altitude-related illness in remote high-altitude locations. These results support pre-travel education on altitude illness and continued investment in field-camp capacity at Himalayan pilgrimage destinations.

***Index Terms*—Acute Mountain Sickness, altitude-related illness, high-altitude illness, medical camp, Himalaya, Uttarakhand, rural health, pilgrimage health**

I. INTRODUCTION

Acute Mountain Sickness (AMS) commonly develops in people who climb rapidly to altitudes above roughly 2,500 meters without sufficient time to acclimatize. It arises from hypobaric hypoxia and usually manifests as headache along with symptoms such as nausea, fatigue, dizziness, or breathlessness. In its more severe forms, AMS can progress into high-altitude cerebral edema (HACE) or high-altitude pulmonary edema (HAPE) - both life-threatening conditions requiring immediate recognition and treatment.

India's Himalayan pilgrimage routes - among them Kedarnath, the Char Dham circuit, Hemkund Sahib, and Amarnath - draw enormous numbers of visitors, many of whom arrive unacclimatized and with limited understanding of altitude-related risk (2,3,6). Research at other Himalayan pilgrimage destinations has found AMS prevalence of about 28% at Hemkund Sahib (4,330 m) and around 34% among pilgrims climbing to Gosainkunda (4,380 m) in Nepal, with some cohorts identifying older age and female sex as contributing risk factors (2,3). Adi Kailash, situated at roughly 14,700 feet within the remote high-altitude terrain of Pithoragarh district near the India-Tibet-Nepal tri-junction, is one such destination. The region features rugged alpine landscape, severe cold, intermittent snowfall, and considerable distance from formal medical facilities - the closest Community Health Centre is about 120 km away, while the nearest paramilitary (ITBP) medical post is roughly 40 km distant.

Although AMS patterns have been studied at several prominent Himalayan pilgrimage sites (2-7), field-level data describing how altitude-related illness actually presents and is managed on-site within remote, resource-constrained camp settings remain limited. This paper draws on data gathered during a 20-day medical camp run by the Seemant Seva Foundation at Adi Kailash to outline the burden, clinical presentation, and management outcomes of altitude-related illness, with the aim of informing the planning of future high-altitude medical camps.

Throughout this paper, we use the term altitude-related illness as an umbrella covering the range of presentations captured by our retrospective, register-based case definition - including AMS-compatible symptom clusters, hypoxemic/respiratory findings, and cases with neurological red flags - rather than assuming a uniform AMS or HACE diagnosis for every patient identified, since the data do not support a definitive clinical diagnosis in each case.

II. METHODS

2.1 Study Setting

The camp ran for 20 days (May-June) at Adi Kailash, Pithoragarh district, Uttarakhand, providing free healthcare to pilgrims, tourists, and local residents alike. Around 1,300 patients were treated over the camp period, during which weather stayed cold with intermittent snowfall.

2.2 Sampling

For detailed analysis, 300 patient records were randomly drawn from the full camp register of roughly 1,300 patients, following the same sampling approach used in the broader camp evaluation this analysis draws from. Each record captured the patient's age, sex, presenting symptom(s)/diagnosis as noted by camp physicians at the time, and place of residence (used to classify patients as local or tourist/pilgrim - residents of Kuti, Pithoragarh, Dharchula, and Gunji were classified as local, with all other locations treated as tourist/pilgrim).

2.3 Case Definition

Since no formal altitude illness scoring tool was used during the camp (such as the Lake Louise AMS Score (1), which requires headache plus a combined symptom score of three or more across four assessed domains), patients were retrospectively classified as having altitude-related illness against register entries using the following case definition, applied consistently across the sample:

- Explicit clinical diagnosis: "acute mountain sickness" recorded by the treating physician; or
- AMS-compatible presentation: headache documented alongside at least one of nausea, vomiting, dizziness, fatigue, or dyspnea/shortness of breath; or
- Hypoxemic/respiratory presentation: documented oxygen saturation (SpO2) of approximately 80% or below, together with headache and tachypnea (rapid breathing).

Within the hypoxemic/respiratory group, patients who also had documented disorientation were additionally noted as showing a neurological red flag consistent with possible severe altitude-related illness (e.g., HACE). Because camp registers did not consistently record this subgroup separately, its exact size could not be tabulated and is reported qualitatively rather than numerically (Section 3.2). This case definition intentionally classifies patients by presentation pattern rather than assigning a uniform diagnosis or severity grade to every hypoxemic patient, since the retrospective, register-based nature of case identification does not support a definitive clinical

diagnosis in each case. This approach, and its limitations, are discussed further in Section 5.

2.4 Data Analysis

Descriptive statistics - frequencies, percentages, means, and ranges - were used to summarize demographic characteristics, presentation category, and management outcome among patients meeting criteria for altitude-related illness. Data were analyzed using standard spreadsheet-based tools.

III. RESULTS

3.1 Prevalence

Among the 300 patient records sampled, 49 (16.3%) met the study's criteria for altitude-related illness.

3.2 Presentation Categories

Category	n	% of altitude-related illness cases
Hypoxemic/respiratory presentation (SpO2 ≤80%, headache, tachypnea)	32	65.3%
Explicit AMS diagnosis recorded	11	22.4%
AMS-compatible presentation (headache + one associated symptom)	6	12.2%
Total	49	100%

Within the hypoxemic/respiratory group, a subset of patients also presented with disorientation - a neurological red flag raising concern for possible severe altitude-related illness such as HACE. This subgroup was not separately quantified in the camp registers, so its size is reported here qualitatively rather than as a distinct numeric category (see Section 5).

3.3 Demographic Characteristics

Characteristic	Finding
Sex	37 male (75.5%) / 12 female (24.5%)
Age, mean (range)	37.8 years (3-71 years)
Age group with highest burden	30-44 years (n=17); 18-29 years (n=13)
Tourist/pilgrim	45 (91.8%)
Local resident	4 (8.2%)

The marked predominance of altitude-related illness among tourists/pilgrims compared with local residents is consistent with the expected protective effect of acclimatization within the resident population.

3.4 Management Outcomes

All 49 patients meeting criteria for altitude-related illness, including the 32 with a hypoxemic/respiratory presentation, were managed entirely on-site at the camp. None required referral or evacuation to the nearest ITBP medical post, despite resource constraints including cold-affected medical equipment and the absence of backup power or refrigeration for medicines.

IV. DISCUSSION

This analysis found that altitude-related illness, by this study's criteria, accounted for a considerable share (16.3%) of morbidity among the randomly sampled patients seen during the 20-day high-altitude camp. This figure sits within the range documented at other Himalayan pilgrimage sites, where AMS prevalence has been reported around 28% at Hemkund Sahib and 34% at Gosainkunda using formal Lake Louise scoring (2,3) - noticeably higher than what was found here, a gap that may partly reflect this study's more conservative, register-based case definition rather than a validated symptom-scoring instrument. Because our case definition spans a range of presentations - from AMS-compatible symptom clusters to hypoxemic/respiratory findings - direct comparison of these prevalence figures with formally-scored AMS studies should be made cautiously. The strong predominance of cases among tourists/pilgrims rather than local residents supports the well-documented role of acclimatization in altitude-related illness risk (2,3,8), and points to non-acclimatized visitors as the group most in need of targeted pre-travel counseling and on-site vigilance. Other studies of Himalayan pilgrimage sites have likewise noted that pilgrims often travel with pre-existing conditions and limited awareness of altitude-related risk, compounding their vulnerability (5,6,7).

One notable finding was the presentation pattern: nearly two-thirds of patients meeting criteria for altitude-related illness had a hypoxemic/respiratory presentation (SpO2 ≤80%), and a subset of this also showed disorientation. Rather than labeling this entire

subgroup as "severe AMS," we describe it here as a hypoxemic/respiratory presentation with a neurological red flag noted in a subset of cases, since the retrospective, register-based data do not allow a definitive diagnosis or severity grade to be assigned to each patient. This pattern may nonetheless suggest that patients were presenting later in the course of illness - potentially reflecting limited awareness of early symptoms, reluctance to interrupt travel or pilgrimage plans, or delayed access to care given the remote terrain. Earlier recognition and treatment at the milder stage could help reduce the burden of hypoxemic presentations in future camps.

Despite these more severe presentations, and despite the logistical constraints noted in the broader camp evaluation - cold-affected medicines and equipment, absence of backup power and refrigeration, and weather-related communication and supply disruptions - every patient meeting criteria for altitude-related illness, including those with hypoxemic/respiratory presentations, was successfully managed on-site with no referrals to the ITBP post 40 km away. This is a notable finding, suggesting that well-staffed and equipped field camps can provide effective frontline management of altitude-related illness, including hypoxemic/respiratory presentations, even in resource-limited high-altitude settings. It should also be read alongside the possibility that the absence of referrals partly reflects sound clinical judgement about which cases could safely be managed locally, rather than evidence that field camps can handle every presentation without any escalation capacity.

These findings align with published recommendations for medical planning at high-altitude pilgrimage sites, which emphasize the value of on-site oxygen supplementation, physician-led triage, and pre-travel education on altitude illness. They also reinforce the importance of maintaining referral pathways and evacuation readiness as a safety net, even when on-site management proves largely sufficient.

V. LIMITATIONS

- Case identification relied on retrospective register review rather than a validated altitude illness scoring instrument (e.g., Lake Louise Score), which introduces potential misclassification in either direction.
- Patients were grouped into presentation categories (AMS-compatible, hypoxemic/respiratory, disorientation/neurological red flag) based on symptom clusters recorded in camp registers rather than a validated clinical or radiological diagnosis; findings therefore describe altitude-related illness presentations rather than confirmed AMS or HACE diagnoses in individual patients.
- The hypoxemic/respiratory category, though clinically defined by the treating team (SpO2 ≤80% with headache and tachypnea), lacked prospectively standardized documentation of every accompanying symptom - including disorientation, which was not consistently or separately recorded - which limits comparability with studies using formal AMS scoring and prevents a precise count of the neurological-red-flag subgroup.
- Findings rest on a random sample of 300 of roughly 1,300 total patients; while sampling aimed for representativeness, some variability cannot be excluded.
- As a single-camp, single-season study, findings may not generalize to other high-altitude sites, seasons, or camp durations.

VI. CONCLUSION

Altitude-related illness represented a substantial share of morbidity at this remote, high-altitude medical camp, disproportionately affecting non-acclimatized tourists and pilgrims, with most cases showing a hypoxemic/respiratory presentation. Despite constraints tied to the terrain and climate, the camp team successfully managed every patient on-site, including those with hypoxemic/respiratory presentations, without any referrals. These findings support continued investment in well-staffed field medical camps at high-altitude pilgrimage and border sites, paired with strengthened pre-travel altitude illness awareness for visitors, as complementary strategies for reducing the burden of altitude-related illness in the Indian Himalaya.

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