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Children at High Altitude: An International Consensus Statement by an Ad Hoc Committee of the International Society for Mountain Medicine, March 12, 2001*

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INTRODUCTION

EACH YEAR MANY THOUSANDS of lowland children travel to high altitude uneventfully. The majority of these pediatric ascents involve trips to mountain resorts, especially in North America and Europe, and a smaller proportion involve journeys to remote highland areas in nonindustrialized nations. In addition, an increasing number of children are moving to reside with their families at high altitude as a result of parental occupation. Although altitude travel is without incident for most, some of these children develop symptoms that may be attributed to altitude exposure, but there has been little documentation in the medical or sci-

*This is an international consensus statement of an ad hoc committee formed by the International Society for Mountain Medicine at the Jasper Park Hypoxia Symposium 2001 and represents the committee's interpretation of the current position with regard to children at high altitude. Readers are reminded that many of the views expressed in this statement are extrapolated from adult data. New data and local and individual circumstances should be considered when using this statement to guide clinical recommendations to patients.

entific literature. Here we outline cases where available.

This consensus statement is concerned with the incidence, prevention, recognition, and treatment of serious altitude illness in the pediatric population. Unfortunately, the particular risks of exposure of children to high altitude have been little studied and much of the advice must necessarily be extrapolated from adult data with due consideration of the influence of growth and development (Berghold, 2000).

The aim of this statement is to offer information for clinicians providing advice concerning altitude travel in the pediatric population. Through better education, parents can make informed decisions regarding travel with their children and can be empowered to detect altitude illness, should it occur.

Definitions

Acute mountain sickness (AMS): An acute illness caused by rapid ascent to high altitude (above 2500 m), characterized in adults by headache, anorexia, nausea and vomiting, fatigue, weakness, dizziness, lightheadedness, and sleep disorder.

High altitude pulmonary edema (HAPE): Acute pulmonary edema caused by altitude hypoxia, presenting as dyspnea, reduced exercise tolerance, cough and hemoptysis, tachycardia, tachypnea, cyanosis and fever, often preceded by AMS.

High altitude cerebral edema (HACE): HACE is also usually preceded by AMS and consists of headache, ataxia, behavioral changes, hallucinations, confusion, disorientation, decreased level of consciousness, focal neurological signs, and coma.

Altitude illness: A collective term that encompasses AMS, HAPE, and HACE

Infants: The term refers to children under the age of 1 year.

1. Acute altitude illness in children

1.1 Incidence of acute altitude illness in children. Large population-based studies of altitude illness among children traveling to high altitude are unavailable, but some data exist from smaller studies (Table 1). The relative lack of prospective data or case studies of altitude illness in children, as compared to adults, may reflect the *relatively* small number of children, normally resident at low altitudes, who are exposed to high altitude. There have been at least 291 cases of HAPE reported in children in the literature, but many of these were in high altitude residents during reascent (see Section 1.1.2).

In addition to the studies of AMS in children that are outlined in Table 1, members of the consensus group are aware of a number of anecdotes in which altitude may have been a contributing factor to significant illness and death. These cases include children with no underlying disease, children with a history of perinatal pulmonary disorders, children with respiratory infections, and children with underlying cardiac conditions. Some of these case reports are sketched in Table 2.

Table 1. Reports of Incidence of AMS and HAPE in Children

Location, altitude (m)	*No. of children (age)*	*No. of adults*	*AMS in children (%)*	*AMS in adults (%)*	*HAPE in children (%)*	*HAPE in adults (%)*	*Reference*
Tibet, 4550	464 (0–15 yr)	5335	34	38.2	1.5	1.27	Wu, 1994
Colorado, 2835	558 (9–14 yr)	0	28*†	8†	0	N/A	Theis et al., 1993; Honigman et al., 1993
Colorado, 3488	23 (3–36 mo)	45	22	20	0	0	Yaron et al., 1998
Colorado, 3109	(3–36 mo) 37	38	19	21	0	0	Yaron et al., 2000

*In this study a control group traveling to a sea-level location reported a 21% rate of symptoms using the same AMS scoring system.

†Ascent from 1600 to 2835 m.

Table 2. Case Reports of Altitude Illness in Children at High Altitude

Location	*Altitude (m)*	*Age of children*	*Number of cases*	*Type of altitude illness*	*Underlying condition*	*Outcome*	*Reference*
Nepal	3450–3900	9–17 yr	6	AMS	None	Recovered	Unpublished observations, J.A. Litch and R.A. Bishop
Nepal	4200	3–6 yr	2	AMS	None	Recovered	Unpublished observations, D.J. Collier and A.J. Pollard
Nepal	4300	3 yr	1	AMS	None	Recovered	Unpublished observations, D. Murdoch
Nepal	4800	12 yr	1	AMS	Resident at 3800 m for 5 mo	Recovered	Unpublished observations, D. Murdoch
USA and Nepal	2500–4243	8 mo–17 yr	>40 cases	AMS	None	Recovered	Unpublished observations, P.H. Hackett
USA	2500–3000	5–11 yr	>20 cases	AMS	None	All recovered, 6 treated with acetazolamide	Unpublished observations, M. Yaron
USA	2500	15 yr	1 case	HAPE	Absent left PA	Died	In press, R. Schoene
USA	1740–3250	2–14 yr	6	HAPE	Down syndrome with pulmonary hypertension or left to right shunt	Recovered	Durmowicz, *Pediatrics* 2001, in press
Nepal	3400	13 yr	1	HAPE	Normally resident at 1500 m	Recovered	Unpublished observations, D. Murdoch
USA	3000	4 yr	1	HAPE	Patent ductus arteriosus	Recovered	Unpublished observations, P.H. Hackett
USA	2750	6, 13, 15 yr	3	HAPE	None	Recovered with oxygen	Unpublished observations, P.H. Hackett
USA	2500–3000	12–22 yr	1 child with 12 episodes	HAPE	Atrial septal defect	Recovered	Unpublished observations, P.H. Hackett
USA	2500–3000	10 mo	1	HAPE, cardiac failure, and possible pulmonary hypertension	Upper respiratory tract infection and possible underlying cardiomyopathy	Died	Unpublished observations, S. Niermeyer
USA	1740–3250	20 mo–16 yr	18	HAPE	2 cystic fibrosis, 2 cancer and recent chemotherapy, 2 recent repair of congenital heart disease, 1 cortisol deficient due to adreno-genital syndrome, 1 hypoventilation syndrome, myelomeningocoele, Chiari malformation	Recovered	Unpublished observations, A. Durmowicz

Table 2. Case Reports of Altitude Illness in Children at High Altitude (Cont'd)

Location	*Altitude (m)*	*Age of children*	*Number of cases*	*Type of altitude illness*	*Underlying condition*	*Outcome*	*Reference*
USA	1740–3250	3–14 yr	8 cases in 6 children	Reentry HAPE	None, high altitude residents	Recovered	Unpublished observations, A. Durmowicz
USA	3000	12-year-old male	1 case	HAPE	Ex-premature infant, broncho-pulmonary dysplasia	Recovered	Unpublished observations, M.W. Eldridge
USA	2800	9-year-old male	1 case	HAPE	Ex-premature infant, broncho-pulmonary dysplasia	Recovered	Unpublished observations. M.W. Eldridge
USA	3400	14 yr	1	HACE	Returned from sea level	Recovered, abnormal EEG	Unpublished observations, A. Durmowicz
Nepal	3400	4 yr	1	HACE/AMS	None	Recovered with descent	Unpublished observation, D. Murdoch

1.1.1. The incidence of AMS in children seems to be the same as that observed in adults (see Table 1; and Theis et al., 1993; Wu, 1994; Yaron et al., 1998; Yaron et al., 2000).

1.1.2. The nature and incidence of HAPE may differ between children resident at low altitude who travel to high altitude and those resident at high altitude who return from travels near sea level. Lowland children probably have no increased risk of HAPE compared to adults. Children resident at high altitude are more likely than adults to develop reentry HAPE (Marticorena et al., 1964; Menon, 1965; Scoggin et al., 1977; Hultgren and Marticorena, 1978; Fasules et al., 1985); these studies involved high altitude *residents* reascending to altitude, rather than low altitude residents journeying to high altitude. The incidence of HAPE in children traveling on the Tibetan plateau was also found similar to adults among the same group (see Table 1; and Wu, 1994). However, intercurrent viral infections may predispose to HAPE (Durmowicz et al., 1997), and such infections are statistically more frequent among young children. Members of the consensus committee report experience of individual cases of HAPE in children.

1.1.3. There is no published information about the incidence of HACE in children and no case reports in the literature.

1.2 Risk factors for acute altitude illness in children. Very little information is available that outlines risk factors for altitude illness specifically in children. Table 3 contains possible risk factors for altitude illness inferred from a few pediatric and some adult studies.

1.3 Symptoms and signs of acute altitude illness in children. At all ages (children and adults) the symptoms of altitude illness are nonspecific and can be confused with unrelated variables, such as intercurrent illness, dietary indiscretion, intoxication, or psychological factors associated with remote travel (Berghold and Schaffert, 1999). However, when ascending with children, it is wise to assume that such symptoms are altitude related and to take appropriate action, in addition to considering treatment for other possible causes.

1. In older children (>8 years), it is assumed that altitude illness will present in much the same way as it does in adults.
2. Under 3 years of age, travel to any new environment may result in alterations of sleep, appetite, activity, and mood. Differentiating behavioral changes caused by travel alone from changes caused by altitude illness can be difficult. Because of variability in the developmental level of perception and expression in young children, they are not reliable reporters of symptoms of altitude illness even when they can talk. Symptoms may appear as nonspecific behavioral changes, rather than specific complaints of headache or nausea. The typical symptoms of acute mountain sickness in very young children include increased fussiness, decreased appetite and possibly vomiting, decreased playfulness, and difficulty sleeping. These symptoms usually begin 4 to 12 hours after ascent to altitude. A modification of the Lake Louise score has been developed that assesses the nonspecific symptoms in very young children and may prove useful in the evaluation of preverbal children; see Appendix B (Yaron et al., 1998). However, at present this score has not been evaluated for routine use by parents or physicians in making decisions about the management of children at high altitude. The score has been validated as having high interobserver agreement when used by parents, and it may be helpful in educating parents about the symptoms of AMS (Yaron et al., 2000).
3. Some older children, particularly those in the age range from 3 to 8 years, and children with learning or communication difficulties may also be poor at describing their symptoms, making altitude illness difficult to recognize.

1.4 Prevention of acute altitude illness in children. There are no studies concerning the prevention of altitude illness in children; however, we assume that prevention principles in adults are also appropriate for children.

1.4.1. Graded ascent. Slow graded ascent, allowing time for acclimatization, is helpful. An

Table 3. Risk Factors for Altitude Illness

Possible risk	*Comment*	*Reference*
Rate of ascent	In adults, rapid ascent is associated with a higher incidence of AMS	Hackett and Rennie, 1979; Maggiorini et al., 1990; Murdoch, 1995a
Absolute altitude gained	In adults, the incidence of altitude illness increases with increasing altitude and with height gain from previous sleeping altitude	Hackett and Rennie, 1979; Maggiorini et al., 1990; Honigman et al., 1993
Exertion	Possible factor in adults	Roach et al., 2000
Cold	Risk factor for HAPE	Rabold, 1989
Preceding viral respiratory infections	May increase the incidence of HAPE among native-lowland children who ascend to high altitude	Zubieta-Calleja and Zubieta-Castillo, 1989; Murdoch, 1995b; Durmowicz et al., 1997
Unilateral absence of the right pulmonary artery or primary pulmonary hypertension	Increases the risk of HAPE	Hackett et al., 1980; Toews and Pappas, 1983; Rios, et al., 1985; Naeije et al., 1996; Sebbane et al., 1997
Perinatal pulmonary hypertension	Perinatal hypoxia and pulmonary hypertension may cause an increased risk of pulmonary hypertension at altitude; this has not yet been associated with HAPE	Satori et al., 1999
Congenital heart disease	Common lesions such as ASD, PDA, and VSD may increase the risk of altitude illness, especially HAPE	See Section 7
Individual susceptibility	Some individuals develop recurrent HAPE that relates to exaggerated hypoxic pulmonary vasoconstriction. It is possible that this may be an inherited susceptibility. A low hypoxic ventilatory response may possibly be a risk factor for HAPE. Impaired alveolar liquid clearance also may contribute to the pathogenesis of HAPE. There are likely to be factors that increase susceptibility to AMS and HACE.	Lakshminarayan and Pierson, 1975; Matsuzawa et al., 1989; Eldridge et al., 1996; Podolsky et al., 1996; Scherrer et al., 1999
Reascent to altitude	Children who normally reside at altitude, who reascend to altitude after a trip to sea level, are at increased risk of HAPE.	Scoggin et al., 1977
Organized groups	Travelers in organized parties may be at an increased risk of dying from altitude illness, probably as a result of reduced flexibility in the itinerary.	Shlim and Gallie, 1992

ascent rate of 300 m per day above 2500 m and a rest day every 1000 m has been recommended, but it is not clear whether a more or less cautious recommendation is more appropriate for children. There are few data on how well children acclimatize to altitude in comparison to adults. Children were found to acclimatize at least as well if not better than adults in one report that recorded the change in heart rate and arterial oxygen saturation of children 7 to 9 years of age and their adult parents during a slow graded ascent (Tuggy et al., 2000).

1.4.2. Drug prophylaxis to aid acclimatization in childhood usually should be avoided, as slower ascent achieves the same effect in most cases and minimizes the unnecessary use of drugs in childhood. In rare cases, when a rapid ascent is unavoidable, use of acetazolamide to aid acclimatization might be warranted in a child. Children with known previ-

ous susceptibility to AMS may benefit from prophylaxis to aid in acclimatization. Side effects do occur with acetazolamide, such as paresthesiae, skin rashes, and possible dehydration; thus use should not be encouraged. Sulfa allergy is a contraindication to acetazolamide use.

1.4.3. Education. Children and their carers should be acquainted with the symptoms of altitude illness and its management prior to altitude travel (above 2500 m). Parents should also know their children's reactions during travel, irrespective of altitude, to be capable of differentiating high altitude illness from simple travel symptoms.

1.4.4. Emergency plan. An emergency contingency plan should be made by all groups traveling to a remote altitude location prior to travel so as to ensure evacuation of a sick member of the party if necessary. Part of the emergency plan should include provision of communications to facilitate evacuation. If a child is traveling to altitude, descent or access to oxygen should be possible immediately (within hours). Altitude sojourns when descent takes days or requires further ascent, prior to descent, should be avoided.

1.4.5. Group travel. School expeditions are a popular educational experience for older children. It is essential that organizations planning school group expeditions to (sleeping) altitudes above 2500 m plan an itinerary that allows graded ascent, rest days, easy descent, and a flexible itinerary in case of illness. Preexpedition planning should include the following:

1. Assessment of past medical history for each child.
2. Education of parents, staff, and children about altitude illness and other expedition health hazards.
3. Wilderness first aid training for staff members and preparation of an appropriate first aid kit.
4. Emergency and evacuation planning, including means of communication in an emergency.
5. Medical and evacuation insurance (applies to all travelers).

1.5 Treatment of acute altitude illness in children. There are no studies of treatment of acute altitude illness in children. However, it seems appropriate to follow adult treatment algorithms with appropriate pediatric drug dosages as outlined below in Table 4.

It may be prudent to be more cautious in managing children with acute mountain sickness and descend earlier after the onset of symptoms than would be the case for an adult, because the natural history of AMS in childhood is not well characterized. Descent, when possible, should involve minimal exertion, which might exacerbate symptoms, and the child should be carried where practical during descent.

2. Symptomatic high altitude pulmonary hypertension

Symptomatic high altitude pulmonary hypertension (SHAPH) includes acute exacerbations of pulmonary hypertension as well as the syndrome of subacute infantile mountain sickness (SIMS) or high altitude heart disease. Acute increases in pulmonary artery pressure have been observed in infants living or traveling to high altitude in association with intercurrent viral infections (Susan Niermeyer, unpublished observation). Treatment focuses on oxygen administration and descent. The subacute form of SHAPH occurs almost exclusively in infants (under 1 year of age) of low-altitude ancestry who are continuously exposed to altitudes over 3000 m for more than 1 month (Wu and Liu, 1955; Khoury and Hawes, 1963; Sui et al., 1988; Wu, 1994). There may be ethnic differences in the risk of SHAPH. Incidence was 1% among Chinese infants at 3050 to 5188 m (Wu, 1994). In this condition, infants develop hypoxic pulmonary hypertension and consequent right ventricular cardiac failure. The presentation begins with poor feeding, lethargy, and sweating. Later, signs of heart failure such as dyspnea, cyanosis, cough, irritability, insomnia, hepatomegaly, edema, and oliguria may become apparent. Management is different from acute mountain sickness

Table 4. Treatment of Altitude Illness in Children

Acute mountain sickness

Mild

1. Rest (stop further ascent) or preferably descend until symptoms cease (particularly with younger children).
2. Symptomatic treatment, such as analgesics and antiemetics.

Moderate (worsening symptoms of AMS despite rest and symptomatic treatment)

1. Descent
2. Oxygen
3. Acetazolamide 2.5 mg/kg/dose p.o. 8 to 12 hourly (maximum 250 mg per dose)
4. Dexamethasone 0.15 mg/kg/dose p.o. 6 hourly
5. Hyperbaric chamber (only used to facilitate descent, which should be undertaken as soon as possible)
6. Symptomatic treatment, such as analgesics (acetaminophen, ibuprofen) and antiemetics in appropriate pediatric doses. Use of aspirin is not recommended in young children, due to the association with Reyes syndrome.

High altitude pulmonary edema

1. Descent
2. Sit upright
3. Oxygen
4. Nifedipine 0.5 mg/kg/dose p.o. 8 hourly (maximum 20 mg for capsules and 40 mg for tabs, slow release preparation is preferred). Nifedipine is necessary only in the rare case when response to oxygen and/or descent is unsatisfactory.
5. Use of dexamethasone should be considered because of associated HACE.
6. Hyperbaric chamber (only used to facilitate descent, which should be undertaken as soon as possible)

High altitude cerebral edema

1. Descent
2. Oxygen
3. Dexamethasone 0.15 mg/kg/dose p.o. 6 hourly
4. Hyperbaric chamber (only used to facilitate descent, which should be undertaken as soon as possible)

Adapted from Pollard and Murdoch, 1998.

and is directed at control of congestive cardiac failure and reversal of pulmonary hypertension. Treatment consists of administration of oxygen, pharmacologic diuresis, and urgent descent.

3. Sudden infant death syndrome (SIDS)

It is unclear whether exposure to high altitude invokes an increased risk of SIDS as there are conflicting reports (Barkin et al., 1981; Getts and Hill, 1982; Kohlendorfer et al., 1998). The prone sleeping position is an important cofactor at altitude as well as at sea level (Kohlendorfer et al., 1998). As at sea level, the risk of SIDS may be reduced by always laying the infant to sleep on the back and avoiding passive exposure to tobacco smoke (Wisborg et al., 2000). The possibility of an association warrants careful consideration of an ascent to altitude with a young (< 1 year old) infant. There is also a theoretical risk and some evidence that exposure to altitude may interfere with the normal respiratory adaptation that occurs following birth (Niermeyer, 1997; Parkins et al., 1998).

4. Cold exposure

Infants and small children are particularly vulnerable to the effects of cold because of their large surface area to volume ratio. The child who has to be carried during a hike is not generating heat through muscle activity and is at risk of hypothermia. Adequate clothing is essential to prevent misery, hypothermia, and frostbite. The committee is aware of a number of cases of frostbite of extremities, including those necessitating amputations (unpublished observations, S. Kriemler; unpublished observations, J.A. Litch).

5. Sun exposure

Reflection from snow and a thinner atmospheric layer at high altitude make the risk of

solar ultraviolet radiation burns more likely than at sea level. Children are more likely to burn than adults if exposed to excess sun. Appropriate sun-block creams (UVA and B, SPF $\geq$ 30, applied before sun exposure), hats and longsleeves, and goggles are required to prevent sunburn or snowblindness.

6. Other factors to consider when traveling in the altitude environment with children

Traveling with children can be very rewarding for both parents and children alike. For many parents who carry their children into the mountains, the trip is an opportunity to relax away from their normal daily activities. However, a number of factors should be considered that may improve the enjoyment of such travel for the children and parents (Berghold and Moravec, 1994).

1. *Boredom*. Young children typically have a short attention span and will easily become bored after traveling relatively short distances. A stimulating itinerary should be carefully chosen.
2. *Physical ability*. Estimates of distances that young children might be expected to walk (at sea level) have been made (Gentile and Kennedy, 1991), but these should only be used as guidelines that may be adjusted for each individual child. It should be emphasized that children should only walk as long as they want to.
3. *Food*. Some young children may be very poorly adaptable to changes in circumstances and refuse unfamiliar food. It is helpful to try foods out prior to altitude travel when possible. It is important to ensure an adequate food and liquid intake.
4. *Hygiene*. In remote treks, traveling with young infants may be particularly stressful for parents trying to maintain appropriate hygiene for their child.
5. *Intercurrent illness*. Gastroenteritis is probably no more common among child travelers than among adults. Children are more prone to develop severe, life-threatening dehydration with gastroenteritis, and supplies to make a safe oral rehydration solution should be part of every medical kit.

7. Children with preexisting illness

Children with certain underlying chronic medical conditions may be at increased risk of developing either an exacerbation of their chronic illness or an illness directly related to altitude, such as HAPE. Few to no data exist for determining the risk for specific medical conditions such as cystic fibrosis or chronic lung disease of prematurity (bronchopulmonary dysplasia). However, by first possessing a knowledge of known risk factors for the development of altitude-related illnesses and then assessing how each individual child's condition may affect his or her cardiopulmonary physiology in a hypoxic environment, it may be possible to determine the relative risk of developing complications at altitude. For instance, both a relative lack of increased minute ventilation at altitude and pulmonary vascular overperfusion, such as is seen in individuals who lack a pulmonary artery, are risk factors for the development of HAPE (Matsuzawa et al., 1989; Selland et al., 1993; Sebbane et al., 1997).

Therefore, it is logical to believe that children with congenital heart defects resulting in overperfusion of the pulmonary vascular bed, such as atrial and ventricular septal defects, unilateral absence of a pulmonary artery, and patent ductus arteriosus, would be at increased risk for the development of altitude-related illnesses like HAPE. Similarly, children who have significant lung disease secondary to premature birth or cystic fibrosis and have elevated Pa_{CO_2} levels at sea level may not be able to increase their minute ventilation when stressed by altitude and thus be at risk for illness at altitude. Children with Down syndrome have a high incidence of both obstructive apnea and hypoventilation, as well as congenital heart defects resulting in increased pulmonary blood flow. Perhaps these physiologic abnormalities contributed to the development of HAPE in children with Down syndrome at relatively low altitudes (Durmowicz, Pediatrics 2001, in press).

Children with noncardiopulmonary disorders may also be at increased risk for the development of illness at altitude depending on how the disorder responds to the stresses of al-

titude. For instance, a child with cortisol deficiency secondary to adrenogenital syndrome developed HAPE at moderate altitude, as did two children with cancer who had recently finished chemotherapy (unpublished observations, A.G. Durmowicz). New onset or recurrent seizures in children who are no longer on medication may occur at as low as 2700 m (unpublished observation, P.H. Hackett). In addition, children with sickle cell anemia appear to be at increased risk for sickling crises at altitude (Mahony and Githens, 1979).

Above all, if parents decide to travel to altitude with children with chronic medical conditions, special planning to ensure adequate supplies and for expedient evacuation is essential. This likely means limiting travels to more developed altitude destinations, rather than isolated backcountry trips.

8. Statement on special considerations for ascent to altitude with children

1 There are no data about safe absolute altitudes for ascent in children.
2. The risk of acute altitude illness is for ascents above about 2500 m, particularly sleeping above 2500 m.
3. Intercurrent illness might increase the risk of altitude illness.
4. Effects of longer-term (weeks) exposure to altitude hypoxia on overall growth and brain and cardiopulmonary development are unknown.

8.1 Location of travel. Travel to high altitude in mountain and ski resorts in industrialized countries with easy and rapid access to medical care should be considered differently from remote travel in isolated mountain ranges and areas without access to a high level of medical sophistication.

1. Most mountain tourist sites and ski resorts in industrialized countries are located at or below about 3000 m, and a majority of travelers to these sites will sleep at about 3000 m or less. Acute mountain sickness is common at this altitude, and there is probably a small risk of serious altitude illness. Once recognized, altitude illness is effectively managed with oxygen and/or descent in most cases. Ascents during tourist activities (cable car rides, travel on mountain roads, and ski trips) to altitudes higher than the resort location, about 4000 m, are usually brief (hours) and probably carry minimal additional risk. Longer trips above 3000 m on foot or horseback should be undertaken with slow graded and cautious ascent to reduce the possibility of altitude illness.

2. Ascents made in remote mountain locations without rapid access to medical care should be undertaken with greater caution. Ascents with sleeping altitudes at or below 3000 m carry a low risk of serious altitude illness; but when HAPE or HACE occurs, management can be more difficult than in developed areas. Higher ascents in this context should be undertaken with slow-graded ascent, rest (acclimatization) days, and careful emergency planning.

8.2 Age of the child

1. Altitude illness is especially difficult to recognize in preverbal children (<3 years), who cannot report classic symptoms of mountain sickness. Similarly, some children from 3 to 8 years may be good at reporting symptoms, but extra caution is required for the younger children in this age range and for children with learning difficulties who will be poor at expressing their experience of symptoms of acute altitude illness. Older children (>8 years) have usually reached the developmental level necessary to report these symptoms.

2. Many preverbal children travel to resorts at 3000 m in North American mountain ranges without complications, but extra caution is required for higher ascents and for ascents in remote areas.

3. For infants in the first few weeks and months of life, there may be some additional theoretical concerns that exposure to over 2500 m for more than a few hours may affect normal respiratory patterns (Parkins et al., 1998).

8.3 Length of altitude exposure

1. Ascents higher than 3000 m that are prolonged (>1 day) or require sleeping above 3000 m increase the risk of acute mountain sickness

and should be undertaken cautiously with slow graded ascent, built-in rest days, and emergency planning.

2. In circumstances where the child is traveling above 2500-m altitude because of parental occupation *and* prolonged altitude residence is anticipated, slow graded ascent as described in Section 1.4 should be undertaken. For infants (<1 year) planning to reside permanently at altitude, some authorities recommend delaying ascent to altitude until beyond the first year of life because of the slight risk of SIMS above 3000 m. This is usually impractical if parental separation is to be avoided. Therefore, after a careful physical exam before ascent and initial acclimatization to high altitude, the infant should be followed closely with respect to growth percentiles; pulse oximetry may be useful, especially during sleep, and the ECG should be monitored periodically for the development of right ventricular hypertrophy.

9. Conclusion

Wilderness travel with children is a rewarding experience for parents and carers when undertaken with adequate preparation. Ascent to altitude adds an extra dimension to such wilderness travel and must be carefully considered. Unfortunately, there are few data to direct guidance, but consideration of a few pediatric studies and extrapolation from adult data provide a framework for safe practice. The consensus view described here provides conservative recommendations that should be helpful for physicians who are required to offer advice about ascent to high altitude with children.

10. Future research directions

The ad hoc committee decided to plan further studies that would provide an evidence base from which to direct future guidelines for children exposed to high altitude. Specific plans were discussed for recording of the epidemiology of altitude illness in children in various populations and locations around the globe. Further validation of CLLS with large populations and different evaluators was thought to be a priority. Study of acetazolamide use in children was thought to be needed, given the use of this drug for rapid ascent to high altitude. An international database is to be developed to collect reports of cases of children with altitude illness coordinated by Michael Yaron (*Michael.Yaron@uchsc.edu*) and Susan Kriemler (*kriemlers@swissonline.ch*).

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APPENDIX A

Lake Louise Acute Mountain Sickness Scoring System

(A) Self-report Questionnaire

1. Headache	0	No headache
	1	Mild headache
	2	Moderate headache
	3	Severe headache, incapacitating
2. Gastrointestinal symptoms	0	No gastrointestinal symptoms
	1	Poor appetite or nausea
	2	Moderate nausea or vomiting
	3	Severe nausea and vomiting, incapacitating
3. Fatigue and/or weakness	0	Not tired or weak
	1	Mild fatigue or weakness
	2	Moderate fatigue or weakness
	3	Severe fatigue or weakness, incapacitating
4. Dizziness or lightheadedness	0	Not dizzy
	1	Mild dizziness
	2	Moderate dizziness
	3	Severe dizziness, incapacitating
5. Difficulty sleeping	0	Slept as well as usual
	1	Did not sleep as well as usual
	2	Woke many times, poor night's sleep
	3	Could not sleep at all

(B) Clinical Assessment

6. Change in mental status	0	No change in mental status
	1	Lethargy or lassitude
	2	Disoriented or confused
	3	Stupor or semiconsciousness
	4	Coma

7. Ataxia (heel to toe walking)	0 No ataxia
	1 Maneuvers to maintain balance
	2 Steps off line
	3 Falls down
	4 Can't stand
8. Peripheral edema	0 No peripheral edema
	1 Peripheral edema at one location
	2 Peripheral edema at two or more locations

(C) Functional Score

Overall, if you had any symptoms, how did they affect your activity?

0 No reduction in activity
1 Mild reduction in activity
2 Moderate reduction in activity
3 Severe reduction in activity (e.g., bedrest)

The sum of the responses to the questions is calculated, and it is recommended that the scores for the Self-Report Questionnaire, the Clinical Assessment (if performed), and the Functional Score be reported separately. A score of 3 points or greater on the AMS Self-Report Questionnaire alone or in combination with the Clinical Assessment score while at altitude over 2500 m constitutes AMS.

APPENDIX B

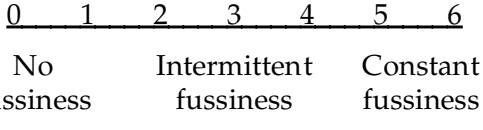
Diagnosis of acute mountain sickness in preverbal children

The Lake Louise Scoring System (LLSS) for acute mountain sickness is useful in adults, but cannot be applied directly to preverbal children (i.e., children <3 years old). The Children's Lake Louise Score (CLLS) was created by modifying the LLSS using a fussiness score as the equivalent of headache, with additional components to assess alterations of eating, playfulness, and sleep. The CLLS is the sum of scores for fussiness (FS), eating (E), playfulness (P), and sleep (S), (CLLS = FS + E + P + S). The parent completes the CLLS, because it is difficult for the clinician to assess these changes in a child's behavior. AMS is diagnosed if the CLLS ≥ 7 with both the FS ≥ 4 and E + P + S ≥ 3.

Children's Lake Louise Score (CLLS)

Fussiness is defined as a state of irritability that is not easily explained by a cause, such as tiredness, hunger, teething, or pain from an injury. Fussy behavior may include crying, restlessness, or muscular tension. Please rate your child's typical fussy behavior **during the last 24 hours** without the benefit of your intervention.

AMOUNT OF UNEXPLAINED FUSSINESS



When Awake

INTENSITY OF FUSSINESS

0	1	2	3	4	5	6
No fussiness			Intermittent fussiness			Constant fussiness

When Awake

FUSSINESS SCORE (**FS**) = amount + intensity

RATE HOW WELL YOUR CHILD HAS **EATEN** TODAY (**E**)

0 Normal
1 Slightly less than normal
2 Much less than normal
3 Vomiting or not eating

RATE HOW **PLAYFUL** YOUR CHILD IS TODAY **(P)**

0 Normal
1 Playing slightly less
2 Playing much less than normal
3 Not playing

RATE THE ABILITY OF YOUR CHILD TO **SLEEP** TODAY **(S)**

0 Normal
1 Slightly less or more than normal
2 Much less or more than normal
3 Not able to sleep

CLLS = FS + E + P + S