Acute Mountain Sickness among Tourists in Lhasa, Tibet

A prevalence study

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ABBREVIATIONS

AMS	Acute Mountain Sickness
HACE	High-Altitude Cerebral Edema
HAPE	High-Altitude Pulmonary Edema
UNWTO	United Nations World Tourism Organization
TAR	Tibet Autonomous Region
LLSS	Lake Louise Score System
ESQ	Environmental Symptoms Questionnaire
P.R.C	People's Republic of China
HAMRQ	Ad Hoc High Altitude Medical Research Questionnare
AMHAD	Acute Mild High Altitude Disease
WHO	World Health Orgnaization
BMI	Body Mass Index
m	Meters
ft	Feets
Vs.	*Versus*

ABSTRACT

Background: The number of visitors to Tibet has been increasing recently and reached to more than six million in 2010. Many of the tourists are not aware of the risk of altitude sickness. The most common altitude sickness to high altitude visitors is acute mountain sickness (AMS), which is unpleasant and may progress to the life threatening condition of high altitude cerebral oedema (HACE) and high altitude pulmonary oedema (HAPE). These problems are of public concern as they have health implications for the health authorities and economic implications for tourism industry in Tibet. Yet, so far no research on acute mountain sickness among tourists has been conducted in Lhasa.

Aim: The study aims to estimate AMS prevalence among tourists and its various subgroups in Lhasa.

Methods: A cross-sectional study was conducted among 2385 tourists in Lhasa who were above the age of 15 years. The participants were recruited in the randomly selected hotels in Lhasa during the time of the study was carried out between the 2nd of June and the 31st of October 2010. The Lake Louise Score System (LLSS) was used to assess AMS. Both English and Chinese version of LLSS-based questionnaire was used for data collection.

Results: AMS prevalence was 50.8% in total sample and 44% in subset two hotels' sample. The AMS prevalence was higher among participants without previous experience of high altitude than with the experience and, in people aged between 20 and 60 as compared with those younger or older and it was more often found in men than in women. The AMS was more common among participants, who arrived in Lhasa by air, who took medication for preventing AMS before coming to Tibet and pain-relieving medication after they arrived in Tibet, and among those who have had previous experience AMS symptoms.

Conclusion: The estimated prevalence of AMS among tourists in Lhasa is high and lies between 44%–50.8% using the LLSS AMS diagnostic standards (headache plus one other symptoms and LLSS≥ 3). The prevalence of AMS was significantly higher in people who rapidly ascend to Tibet, middle aged, experienced at high altitude and previous AMS symptoms.

CHAPTER I BACKGROUND

A large and increasing number of tourists are travelling to Tibet (2) and other high altitude areas around the world; many without knowing about the risk of developing acute mountain sickness (AMS). In Tibet nowdays international and domestic tourists as well as immigrants of Han Chinese origin and their family and friends constitute risk groups for the development of AMS. Lhasa, one of the world's highest cities, and the capital of Tibet Autonomous Region (TAR), is the first destination of most vistors to Tibet. Knowledge about the prevalence of AMS among these visitors is of importance for planning of health services. Furthermore, knowledge about risk factors and protective measures for AMS will help the health authorities in Tibet to provide the best advice and treatment for immigrants and visitors. Health personell in general, locally and abroad, may utilise such knowledge to inform tourists who plan to travel to high altitude areas.

AMS is known as a combination of non-specific symptoms like gastrointestinal symptoms (loss of appetite, nausea, or vomiting), headache, insomnia, dizziness, and lassitude or fatigue, but without abnormal neurological findings (3;4). Altitude level, speed of ascent, and individual susceptibility, awareness, general state of health, age, gender, and obesity have been found to be associated with AMS (3-6). AMS is largely preventable and most AMS patients recover after simple treatment. However, some cases may progress to high-altitude cerebral edema (HACE) and high-altitude pulmonary edema (HAPE), which are life threatening (4;7).

Studies of the prevalence on AMS among tourists, trekkers, railway construction workers, and army populations have been carried out in many other countries and areas (8-22). With an altitude of 3649 meters above sea level and located the north face of Mt. Everest in the Himalayas, the altitude and climate in Lhasa is a challenge to tourists. Another challenge for most visitors is to Tibet's main city of culture and religion, Lhasa is that certaion ways of travell to Tibet do not allow for gradual acclimatition. Most go by plane directly to Lhasa. Going by railway gives a slightly more gradually ascent as it take about 30 hours from the last low land station to Lhasa. Compared to research among army members and trekkers (15;20;23), tourists in Lhasa are more heterogenous group, constituting of people of different ages, with and without chronic diseases, and include some on medications against AMS.

Prior to the current study, two Norwegian students from Medical Faculty of Oslo University (UiO), conducted a pilot study of AMS among 30 subjects in Lhasa in the early spring in 2008 (24). The pilot offered important information for the planning of the current study.

The present cross-sectional study aims at giving the prevalence of AMS among the study population of tourist and its various subgroups in Lhasa.

CHAPTER II INTRODUCTION

1. General information about Tibet

The three major high-altitude regions in the world are the Himalayas in Asia, the Andes South America and the Rocky Mountains in North America. The Himalayans and its northern Tibetan plateau, where the research site is located, is the highest and largest high altitude plateau in the world. Altitude divided by levels according to their sea level is as follow (5;25):

a. Intermediate: 150–2500 m (4921–8202 ft.);

b. High: 2500–3500 m (8202–11483 ft.);

c. Very high: 3500–5500 m (11483–18045 ft.);

d. Extreme: 5500–8850 m (18045–29035 ft.) or more.

1) Tibet

Tibet, in Tibetan is called "*bod*" and in Chinese *"Xizang"*. This can refer to all three traditional parts of Tibet, including U-Tsang, Amdo and Kham. Only U-Tsang is what corresponds to Tibet Autonomous region (TAR) today, established in 1965, while other areas of Tibet today are part of the four provinces of Qinghai, Sichuan, Gansu and Yunnan. In this thesis I will use the term Tibet interchangeably with the TAR. Tibet features an average elevation that exceeds 4900 m (16000 ft) (26), and has therefore often been called the "Roof of the World". The south and the west of the plateau bordered the mighty Himalayas and to the north the Kun Lun Mountains. Covering an area of 1.22 million square kilometres, the TAR is divided into one city and seven prefectures. These are Lhasa city, and the prefectures of Nagchu, Chamdo, Nyingtri, Lhoka (also called Shannan), Shigatze and Ngari (Figure 1).

According to the 2010 national census, the TAR has more than three million (3,002,166) inhabitants and most of them are Tibetans (90.48%)(27), 8% of inhabitants are Han Chinese (27). Tibetan and Mandarin Chinese are the main languages used in TAR and the dominant religion is Tibetan Buddhism.

The economy of Tibet is still largely based on agricultural subsistence, though there are vast pastoral regions as well. Tourism has become a growing industry in Tibet in recent decades and it is planned to be one of the main industries in Tibet (28;29).

2) Lhasa

Lhasa ("*Lhasa*"in Tibetan and "*Lasa* 拉萨" in Chinese) is the capital of TAR. It is located on the northern bank of the Kyichu River (also called Lhasa River), a tributary of the Yarlung Tsangpu River (also called Brahmaputra). The city was founded 1300 years ago, and covers 30000 square kilometres, with a central area of 544 square kilometres. The estimated population in 2010 was 559,423 (27). The elevation of Lhasa at 3649 meters above sea level makes it one of the highest cities in the world. The average yearly temperature is 8.5° C, and Lhasa has an annual average of 3021 hours of sunlight. Lhasa has acted as the centre of Tibetan politics, economy, culture, transport and it is an extremely important and sacred site for Tibet's Buddhism. Lhasa contains many culturally significant Tibetan Buddhist sites such as the Potala Palace, Jokhang and Norbulingka Palace.

Lhasa city consists of Chengguan district, which equals urban Lhasa and seven small counties: Lhündrup, Damshung, Nyemo, Chuchul, Thölung, Taktse and Medrogongkha counties. The central and urban part of Lhasa, also called Chengguan District, is the location of the administration of the prefecture and the whole of the TAR. The largest airport of TAR is situated about one hour drive outside Lhasa, and Lhasa features the terminal station of the Qinghai-Tibet railway as well as the Qinghai-Tibet, Sichuan-Tibet and Yunnan-Tibet motorways (Figure 2).

3) Health care facilities in Lhasa

In Tibet, the general standard of hospitals is still not very high, but treatment of altitude sickness can be sought in several health care facilities in Lhasa. There are three high level hospitals: The 'First TAR People's Hospital' which has an emergency treatment center for altitude sickness; 'TAR People's Liberation Army General Hospital' with an high altitude research center; and the Department of Respiratory Disease at the 'TAR Armed Police General Hospital'. Some mid-level hospitals such as the 'Second TAR People's Hospital'; an affiliated hospital of the 'Tibetan Medical and Astrological Institute' (*"Mentsikhang"* in Tibetan); and the 'Lhasa City People's Hospital' also have the ability to treat mild and moderate forms of AMS. Two private hospitals and a number of private clinics provide oxygen and other medication for the treatment of AMS.

Figure 1. The location of Lhasa in TAR *(Adapted from* China tour. http://www.chinamandarintours.com/china-guide/Tibet/)

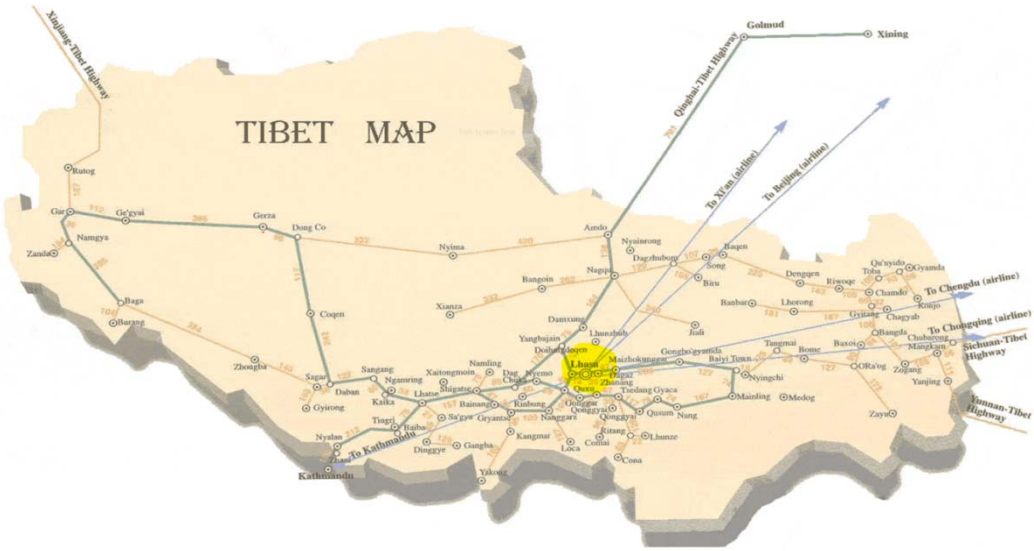

Figure 2. Map of main roads to Lhasa *(*The Qinghai-Tibet Railway line along with Qinghai-Tibet Highway. *Adapted from* Dreams Travel Tibet & Sichuan.: *http://english.dreams-travel.com/guide/tibet/map_tibet2.htm*)

4) Tourism in Tibet (Lhasa)

Tibet, with its fantastic and spectacular landscapes and unique cultural characteristics, has become popular a tourist destination. In terms of changing travel habits, politics, economy and development of the railway to Lhasa in 2006, the city has recently become a major destination for what one could call 'ordinary' travellers, such as immigrants from the lowlands, especially from inland China, and their family and friends who come to visit them.

According to surveys by the National Statistical Bureau of China, the number of tourists from mainland China and abroad to TAR has increased sharply from approximately 690,000 in 2001 to 4,020,000 in 2007 and to more than 6 million in 2010 (30) (Figure 3). Based on the Tourism Development Plan for the TAR of the year 2008, the the government authorities are

planning a remarkable growth in tourism to the region, with a goal of 10 million visitors in total, 9 million from China and 1 million from abroad by 2020.

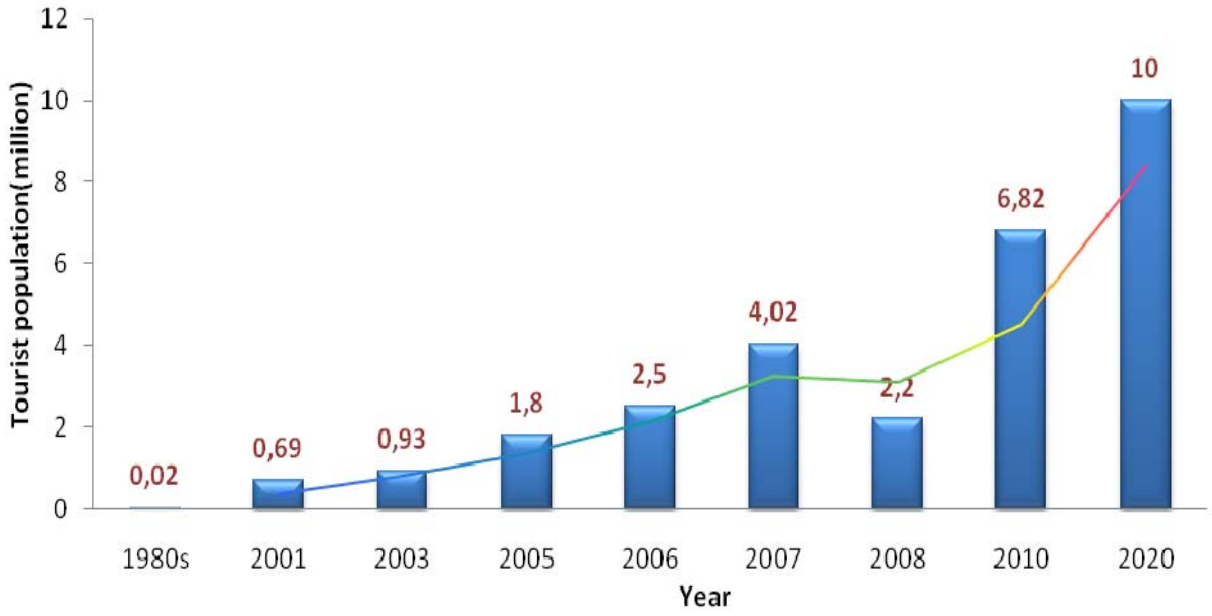

Figure 3. The number of tourists in Tibet 1980s- 2020 (by million)

(Data available from National Statistic Bureau of China(www.stats.gov.cn) and Tibetan tourism development masterplan (Beijing Daily: www.bjd.com.cn on 10 June,2005)

Hotels, lodges and guesthouses are crucial facilities for any tourism industry. In Tibet, the number of hotels is increasing. Most tourist facilities in Tibet are located in Lhasa. In the city of Lhasa, there are a number of guest houses and 90 star-rated hotels (31).

2. Acute mountain sickness

1) Definitions of AMS

Acute mountain sickness (AMS) is a common affliction in otherwise healthy people who ascent rapidly to high altitude areas. According to the Lake Louise Consensus on AMS, arrival of a person who is not used to altitudes of more than 2000 meters above sea level and reaches there may experience a combination of non-specific symptoms including headache, gastrointestinal symptoms (loss of appetite, nausea, or vomiting), insomnia, dizziness, and lassitude or fatigue (4;6;25;32), but without abnormal neurological presentation (3). The symptoms typically develop within six to ten hours (32) between six and twelve hours (4) after ascent, and sometimes even as early as within one hour (32). The symptoms mentioned

above are usually most pronounced on the second or third day (5), and they often disappear by fifth day. In serious cases AMS will progress to high-altitude cerebral edema (HACE) and high-altitude pulmonary edema (HAPE) which are much less frequent than AMS, but are potentially fatal (4).

There is no golden standard in the form of a biological marker for the diagnosis of AMS. Several definitions and different scoring systems of AMS have been developed in order to measure AMS. These are based on subjective reports of typical symptoms, and possibly a physical examination by health professionals who have good knowledge of altitude sickness. Questions about symptoms can be recorded either through self-reporting forms, or by an investigator. Prevalence of AMS is confirmed if AMS scores exceed a defined limit. Clearly defined scoring systems make it possible to compare results from different studies if identical methods are applied.

The Lake Louise Scoring System (LLSS) (3) and the The Environmental Symptoms Questionnaire (ESQ) (33) are used most comonly and are recommended (1). There exist also ohter AMS scoring systems like the Hackett's Questionnaire (34) and the Chinese ad hoc 'high altitude medical research questionnare' (HAMRQ) (20).

The so-called 'Hackett Questionnaire' (34)was developed for the surveys Hackett carried out in the 1970s in order to map AMS. It consists of a brief structured interview about headache, nausea, vomiting and dizziness. In addition, it includes a physical examination on edema, respiratory rate, lung and ataxia. The diagnosis of AMS according to Hackett is based on a combination of the results of the interview scores and the physical examination (35). Review of recent literature shows that only few studies use Hackett's AMS system.

Table 1. *Eleven Questions of the ESQ-III pertaining to Altitude Sickness.*

1. I feel lightheaded
2. I have a headache
3. I feel dizzy
4. I feel faint
5. My vision is dim
6. My coordination is off
7. I feel weak
8. I feel sick to my stomach
9. I lost my appetite
10. I feel sick
11. I feel hung over

Source: Dellasanta et al., 2007 (1).

The Environmental symptoms questionnaire (ESQ)

The Environmental Symptoms Questionnaire (ESQ) was developed in the early 1980s (1). The purpose was to create a standardized system to assess symptoms that soldiers experienced in extreme environments (36). The questionnaire has since then been revised and the current version is the third version (ESQ-III). It consists of 67 questions, but only eleven are relevant for assessing AMS (Table 1). The answers are rated from zero (not present) to five (extremely severe), but are weighted in a special manner when

the aim is to assess AMS (using an assigned factor numbers). To assess whether a person has AMS or not, one must calculate a score called AMS-C (C stands for cerebral symptoms). To obtain the AMS-C score, the sum of all item scores multiply by the respective factorial weight, and are then multiplied by five and divided by 25.95. In ESQ-III, AMS is defined if the AMS-C ≥ 0.7.

ESQ -III can be either administered by an investigator, or could be used in the form of a self-report form. Both thoese methods have been shown to give equally good results. In addition, a recent study (37) has been conducted to compare the 67 questions and an electronic version containing only the eleven questions that are relevant to altitude sickness. It shows that there is significant agreement between the two versions, and concludes that the online short version can be used in place of the full version, when studying the prevalence of AMS (37).

Lake Louise score system (LLSS)

At a scientific conference (the 'International Symposium on hypoxia') at Lake Louise, Canada, in 1991, an agreement was reached on a simpler questionnaire than the one previously used but also one that would be more complex than the above-mentioned 'Environmental Symptoms Questionnaire' (ESQ). Adjustments were made at the next conference in 1993. The Lake Louise Consensus Group describes an AMS self assessment, which can be supplemented by a clinical assessment and a functional score (37;38) (Table 2). The LLSS "is based on the quantification of the reported subjective sensation of the severity of symptoms" (33). It can be self-reported or used in combination with a clinical assessment.

Lake Louise AMS self assessment consists of only five questions (Table 2). These are based on the most common symptoms of AMS: headache, gastrointestinal upset, insomnia, weakness or fatigue, and dizziness or lightheadedness. There are four alternative answers to each question. When the responses are analyzed, there will be zero, one, two or three points to each question. A complete response will be an AMS self-reporting scores from zero to fifteen.

According to the Lake Louise Consensus Group, AMS is defined as the presence of headache in an unacclimatized person who has recently arrived at an altitude above 2500 m, and the presence of one or more of the following: gastrointestinal symptoms (anorexia, nausea, or vomiting), insomnia, dizziness, and lassitude or fatigue. Accodring to the Lake Louise Score System, there have to be at least two of these symptoms present (38).

Table 2. **Lake Louise Score System (LLSS) for the diagnosis of acute mountain sickness (AMS)**

(a) AMS self assessment
(A rise in altitude within the last 4 days and presence of headache. In addition there has to be the presence of at least one other symptom and a total score of three or more from the questions below.)

Symptom	Score	Question
Headache	0	None at all
	1	Mild headache
	2	Moderate headache
	3	Severe headache, incapacitating
Gastrointestinal symptoms	0	No gastrointestinal symptoms
	1	Poor appetite or nausea
	2	Moderate nausea or vomiting
	3	Severe nausea or vomiting, incapacitating
Fatigue and/or weakness	0	No tired or weak
	1	Mild fatigue/weakness
	2	Moderate fatigue/weakness
	3	Severe fatigue/weakness, incapacitating
Dizziness/light-headedness	0	No dizzy
	1	Mild dizziness
	2	Moderate dizziness
	3	Severe dizziness, incapacitating
Difficulty in sleeping	0	Slept as wee as usual
	1	Did not sleep as well as usual
	2	Weak many times, poor night's sleep
	3	Could not sleep at all

(b) Clinical assessment

Change in mental status	0	No change
	1	Lethargy/lassitude
	2	Disorientated/confused
	3	Stupor/semiconscious
	4	Coma
Ataxia (heel/toe walking)	0	None
	1	Balancing manoeuvres
	2	Steps off the line
	3	Falls down
	4	Unable to stand
Peripheral edema	0	None
	1	One location
	2	Two or more locations

(c) Functional score
(An optional question can be either by check or by self-report section.)

Overall, if you had any of these symptoms, how did they affect your activities?	0	Not at all
	1	Mild reduction
	2	Moderate reduction
	3	Severe reduction (e.g. bedrest)

Source: Roach RC al., The Lake Louise acute mountain sickness scoring system. 1993, (36).

The Chinese scoring system

The Chinese Medical Association developed the so-called Ad Hoc 'High Altitude Medical Research Questionnare' (HAMRQ) based on the LLSS in 1995 (Table 3), which was adjusted in 1996 (20). In the Chinese scoring system, 'acute mild high altitude disease' (AMHAD) is equivalent to AMS in LLSS. The degree of AMHAD based on HAMRQ is given as the "Severity of Acute Mountain Sickenss" (Table 3). For instance, mild AMS is diagnosed as the presence of headache or vomiting that affect the functioning of daily activities. When either symptom is absent, a score between five and ten is required for the diagnosis of mild AMS, with one score assigned for each of the following symptoms: dizziness/light-headedness, nausea, palpitation, shortness of breath, chest tightness, dazzling/blurredvision, sleeplessness (insomnia), anorexia, abdominal distension, diarrhea, constipation,cyanosis of the lips, lethargy, and numbness of the extremities (39).

Table 3. The Chinese acute mountain sickness scoring system

(a) Acute Mild High Altitude Disease (AMHAD) Scoring System

	Symptoms	Severity	Score
Headache	No headache, no suffering expression, no effect on daily activity.	±	1
	Mild headache with suffering expression; obvious improvement of headache after taking regular analgesic medicine; no effect on daily activity.	+	2
	Moderate headache with suffering expression; slight improvement of headache after taking regular analgesic medicine; daily activity is affected.	++	4
	Severe and unbearable headache; lie in bed and cannot get up; no effect of regular analgesic medication.	+++	7
Vomiting	Vomiting 1 to 2 times a day; vomit contains only intake food; obvious improvement with regular anti vomit medication; no effect on daily activity.	+	2
	Vomiting 3 to 4 times a day; final vomit contains gastric juice; slight improvement with anti vomit medication; daily activity is affected.	++	4
	Vomiting more than 5 times a day; must lie in bed and cannot get up; no improvement with regular anti vomit medication.	+++	7
Others	Dizziness/light-headedness, nausea, palpitation, short breath, chest distress, dazzling/blurred vision, sleeplessness (insomnia), anorexia, abdominal distension, diarrhea, constipation, cyanosis of the lips, lethargy, and numbness of the extremities	+	1 point each

(b)Severity of Acute Mountain Sickness

Severity	Scoring
Normal (±)	1 to 4
Mild (+)	Headache (+) or vomiting (+) or total score 5 to10
Moderate (++)	Headache (++) or vomiting (++) or total score 11 to 15
Severe (+++)	Headache (+++) or vomiting (+++) or total score >16

Source: West JB, English Translation of Nomenclature, Classification, and Diagnostic Criteria of High Altitude Disease in China.(37).

Summary of the definition

HAMRQ is used by some Chinese scholars (20;22) and articles with HAMRQ were also recently published in western scientific journals. They argued that it is more inclusive and less subjective than LLSS (20). However, according to a recent debate on headache and AMS, the three scientists Robert Roach, Peter Hackett and Bengt Kayser assessed the Chinese scoring system to be in the same category with EQS (40).

Although LLSS provides an AMS diagnostic standard, various other definitions of AMS are used in the scientific literature: some define AMS as a conditions that needs to present witjh more than the three symptoms required by LLSS (11;41), others, such as Maggiorini, defines AMS as an ailment of more than two LLSS symptoms among Alpine mountaineers (15) (For more details, see Table 4 and 5).

Overall, ESQ-III is more complicated than LLSS. LLSS main questions are similar to Hackett's Questionnaire. According to the literature and, since the 1991 Lake Louise consensus on AMS, most researchers use LLSS or LLSS based questionnaires.

2) Epidemiology of AMS

Incidence or prevalence?

The terms and concepts of AMS 'incidence' or 'prevalence' are used interchangeably in AMS related literature. Hardly any article discusses which one of the two would be preferable to describe the currency of AMS.

Prevalence is a frequently used epidemiological measure to describe the total number in a defined population afflicted with a particular disease or condition. This is further specified and described when occurring at a stated point in time as the so-called 'point prevalence', when occurring during a given period of time as 'period prevalence', or if the condition has occurred during the life time, it is named 'life time prevalence'. Point prevalence is usually expressed as a rate, the denominator being the number of persons in the specified population at that point of time (42). For example, AMS questionnaires were distributed among 200 tourists who lived in the Old Mandala Hotel in Lhasa in July, 2010. *100* tourists out of 200 had AMS, i.e. the AMS prevalence in Old Mandala Hotel was 50%.

Incidence is another concept usually used when measuring the rate of occurrence of *new* cases of a disease or condition over a defined span of time in a specified population. Incidence may

be expressed as the cumulative incidence, the denominator being the average number of persons in the specified population during the defined period or the estimated number of persons at the mid-point of that period who present a certain condition or disease (42). For example, 10000 people who had just arrived in Lhasa were followed during my study for four days. 250 out of the group were diagnosed with AMS during those four days, i.e. the incidence of AMS among this group in Lhasa was 250 per 1000 that is 25%. Incidence may also be expressed as the incidence rate which is the number of new cases divided by the total number of people followed over a defined period of time.

Incidence and prevalence are different, yet related. Prevalence means about the same as incidence, but is multiplied by the disease duration. For diseases that last for a long time or chronic diseases, such as cardiovascular disease or diabetes, the prevalence is significantly higher than incidence. For diseases that last only a short time, such as colds, prevalence is approximately equal to incidence. Therefore, for acute diseases like AMS, prevalence equals incidence (43).

Prevalence of AMS in global comparison

The prevalence of AMS among adults varies between 3% and 93% in studies conducted at different altitude levels applying different methods (4;10;25;44). Studies on AMS in trekkers, army, railway construction workers and tourists have been done in America, Europe, Asia, Africa and New Zealand (8-22) (Figure 4).

Table 4 shows estimated prevalences of AMS among tourists in North American Rocky Mountains, the Nepalese Himalayas, in Hawaii, in La Paz, Bolivia and inTibet.

Honigman *et al*. examined the prevalence of acute mountain sickness among tourists in the Rocky Mountains, Colorado in 1993 (11). The authors pointed out that their study was the largest study of tourists traveling to moderate altitudes. The study populations were the attendees of various conferences around Colorado. During a two-year period, a total of 4212 adults took part in their studies. They were recruited from 45 conference hotels situated between 1920 and 2950 meters above sea level. The questionnaires were distributed to participants of conferences within 48 hours after arrival. Brief information about the study project was given and questionnaires were collected later in the same resort. A Total of 3158 questionnaires (75%) were completed.

AMS was defined as the presence of three or more LLSS symptoms. 25% percent of conference attendees developed AMS, and of them, 65% within the first twelve hours after

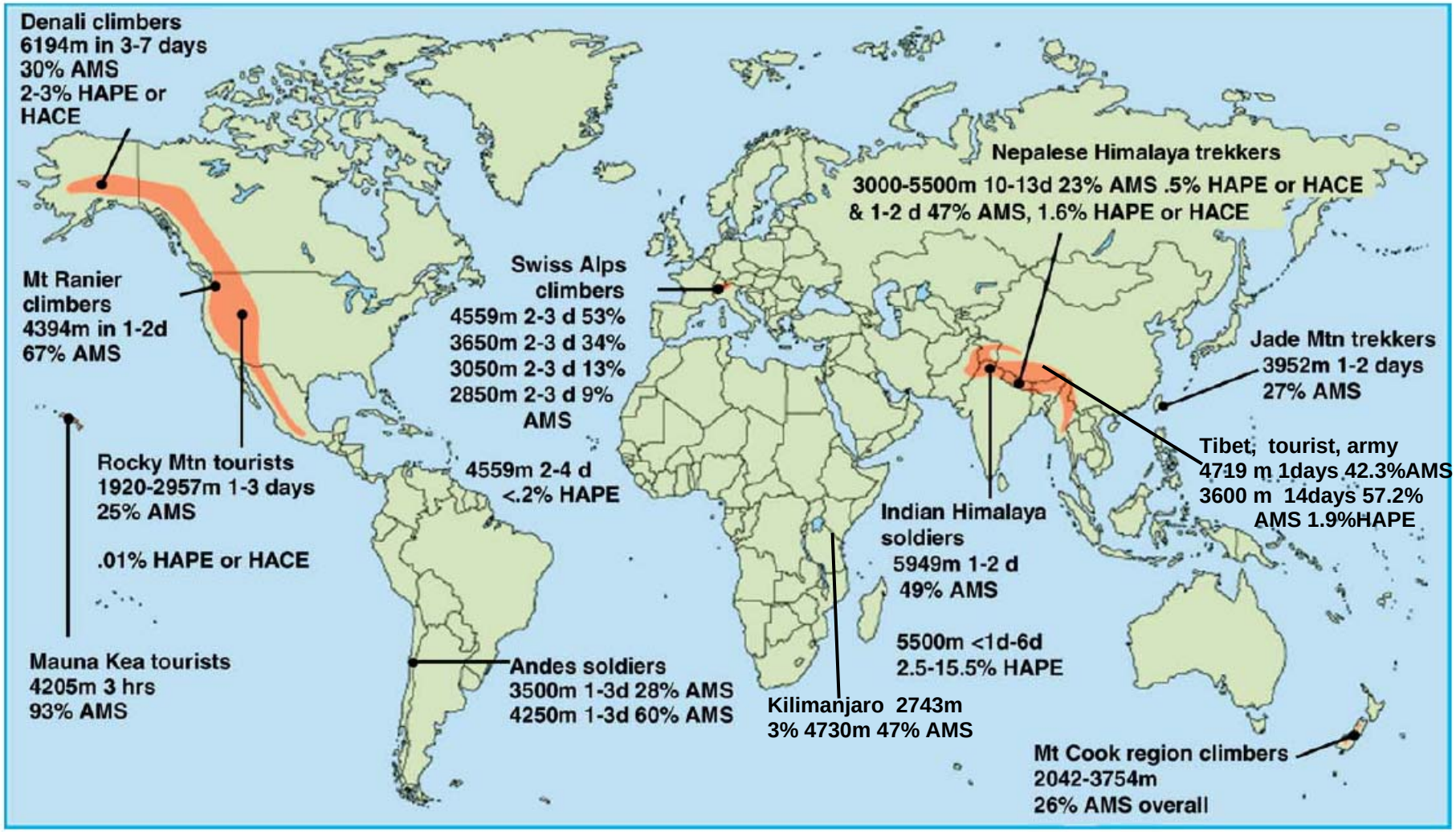

Figure 4. Global acute mountain sickness incidence reports.(*Adapted from* Gallagher SA, Hackett PH. High-altitude illness (5). Additional data on Tibet and Kilimanjaro site. (14;20;44).

arrival. Of those with symptoms, approximately half reduced their physical activity. The prevalence of AMS was higher among those with permanent residence under 914 meters, previous AMS experience and lung disease, and in the attendees of young age, as well as among women and those with poor or average physical condition.

According to the study of Hochedez *et al.* 2004 (45), the prevalence of AMS was reported for the years 1984 and 2001 among French Travelers to Nepal. 50% of these, who visited a doctor at the French Embassy in Kathmandu in 2001, had symptoms of altitude sickness as compared with no altitude sickness cases reported in 1984. Another study conducted in 1986 by Bengt Kayser (23) among 530 western trekkers visiting the Thorong pass in Nepal (5400m above sea level) showed that 63% had AMS according to the definition of AMS by ESQ-III.

The Survey of AMS on Mauna Kea,Hawaii (19), a 4200 meters high volcano tourist attraction reported a prevalence of 30% among day visitors and 69% professional astronomy staff. It takes less than two hours to drive to the peak. In a two-day data collection, approximately 350 English-speaking tourists were handed questionnaires along the road up to the top of the vulcano. The forms were then returned at a collection point, or submitted by mail afterwards. A total of 198 questionnaires was collected. In this study ASM was defined as a per LLSS standards, i.e. more than two of the symptoms of AMS, in addition to the presence of headache and of one other symptom.

Carlsten *et al*. conducted a study in La Paz Bolivia located at 3630 m (46), a city at similar altitude to Lhasa, Tibet. The study's primary aim was to determine the effect of acetazolamide as a prophylaxis for AMS. Immediately after participants' arrival in La Paz, 32 individuals were included in the study and nine of them had AMS. AMS was defined accoring to Lake Louise Symptom Score (i.e. more than two symptoms).

One AMS study has been carried out among tourists in Tibet. It was conducted by a Chinese Master's student in 2008 at the Namtso Lake Tour Zone (4,718 m) and among 310 one-day Chinese tourists (14). It reported an AMS prevalence of 42.3% used LLSS. Furthermore, 82% of participants who suffered from AMS experienced the onset of AMS symptoms within the first hour of arrival at the altitude of the study area.

In addition to this study there are two recent articles in international journal. One is a study of AMS in Qinghai-Tibet railway construction workers (22). In this article Wu and colleagues broadly discuss AMS based on data from 14,050 workers of the world's highest railway

construction project. The railway goes from Golmud (2808 m) to Lhasa (3649 m) and in total is 1142 km long. 85% percent of the railway is situated above 4000 meters and its highest point is the Tanggula Pass at 5072 meters. The construction of the railway was completed at the end of 2005 and the study had taken four and half years to be completed.

The study reports that 80% of the workers had been born and raised in the lowlands (below 760 meters) and had never been exposed to high altitude in the past.

The workers were mainly men (98.8%), aged 20 to 62 years. Prior to signing contracts by the workers, the researchers had undertaken a health screening for all workers. Contraindications for employment were screened for hypertension (systolic ≥ 160 and / or diastolic ≥ 95); certain forms of arrhythmia; angina pectoris; certain ECG findings; diabetes; ulcers; chronic liver disease; COPD; pregnancy; and epilepsy. To allow a better acclimatization for all workers from the lowlands, the ascent to the plateau took place gradually over eight days before their work shift started. All workers were advised to avoid hard physical activity the first week after arrival at altitude.

Questionnaires were completed between two and three hours after the first arrival of the workers at the construction site and then every night before sleeping for eight weeks. To determine the prevalence of AMS, the Lake Louise questionnaire was used, and AMS was defined as a score of ≥ 3 symptoms and the presence of headache. According to the study, the prevalence of AMS was 51% on initial exposure, that of HACE 0.3% and HAPE 0.5%. The prevalence among people with obesity is shown to have been much higher than in people with normal BMI.

Another AMS study was conducted in Tibet by Ren Yi. *et al.* in 2009 (20). The study was carried out among Chinese soldiers who arrived to in Tibet at an altitude of 3600 meters. The study investigated 3628 unacclimatized soldiers who have never been exposed to high altitudes and who arrived by air. The Chinese Ad Hoc High Altitude Medical Research Questionnaire (HAMRQ) was used for the data collection. The data were collected two weeks after the arrival. Physical examination and appropriate laboratory tests were also performed for hospitalized subjects. 2063 (57.2%) of the soldiers had mild acute mountain sickness and 249 (12.07%) of them were hospitalized for treatment. The prevalence of HAPE was 1.9%, while HACE and death were not reported. Psychological stresses and excessive physical exertions possibly contributed to the onset of HAPE.

So far, there is no AMS study has been conducted among tourists or ordinary population in Lhasa, a major gap that this master thesis is aimed to address.

Table 4. The prevalence of acute mountain sickness (AMS) among tourists

Studies	Publish Year	Site	Altitude (m)	Whom	Number	Definition AMS	Time of arrival	AMS prevalence (%)
1	1993	Rocky Mountains, Colorado	1920-2950	Conference attendees in 45 conference hotels	3158	≥3 LLSS symptoms	< 48 hours	25
2	2004	Nepal	Not Given	All French tourists i Nepal in 2001	21457	LLSS: headache and one of other symptoms	Not Given	15
3	1991	Nepal	5400	Trekkers to Thorong Pass	530	ESQ-III	The eighth day	63%
4	2007	Mauna Kea, Hawaii	4200	Tourists	198	LLSS: headache plus one of other symptoms and score at least three.	< 24 hour	30 (day visitors) and 69 (professional astronomy staff)
5	2004	La Paz, Bolivia	3630	Tourists by air from Miami, USA	32	LLSS: headache plus one of other symptoms and score at least three.	2 hour	28
6	2008	Namtso Lake Tour Zone , Tibet	4718	Chinese Tourists	310	LLSS: headache plus one of other symptoms and score at least three.	< 24 hour	42.3
7	2007	Tibet	+/- 4000	Railway construction Workers	14050	Chinese standard: HAMRQ	2-3 hours, + every ninght for 8 weeks	51
8	2009	Tibet	3600	Chinese new army to Tibet	3628	Chinese standard: HAMRQ	2 hours	57.2

Studies:

1. *Acute mountain sicknesss in a general tourist population at moderate altitudes (11).*
2. *Changes in the pattern of health disorders diagnosed among two cohorts of French travelers to Nepal, 17 years apart (45).*
3. *Acute mountain sickness in western tourists around the thorong pass(5400m) in Nepal* (23).
4. *Survey of Acute Mountain Sickness on Mauna Kea* (19).
5. *A dose-response study of acetazolamide for acute mountain sickness prophylaxis in vacationing tourists at 12,000 feet (3630 m)* (46).
6. *An epidemiological investigation of acute mountain sickness in tourist population in Lake NaMuCuo (Namtso) in Tibet, P.R.China* (14).
7. *Who should not go high: chronic disease and work at altitude during construction of the Qinghai-Tibet railroad* (22).
8. *Incidence of high altitude illnesses among unacclimatized persons who acutely ascended to Tibet* (20).

LLSS: Lake Louise Scoring System

3) Determinants of AMS prevalence

High altitude, fast speed of ascent, and lack of acclimation are major determinants of AMS susceptibility, while some studies also show an association with general states of health, age, gender, and obesity (Figure 5). The reason for the considerable variation in individual susceptibility is currently poorly understood (3).

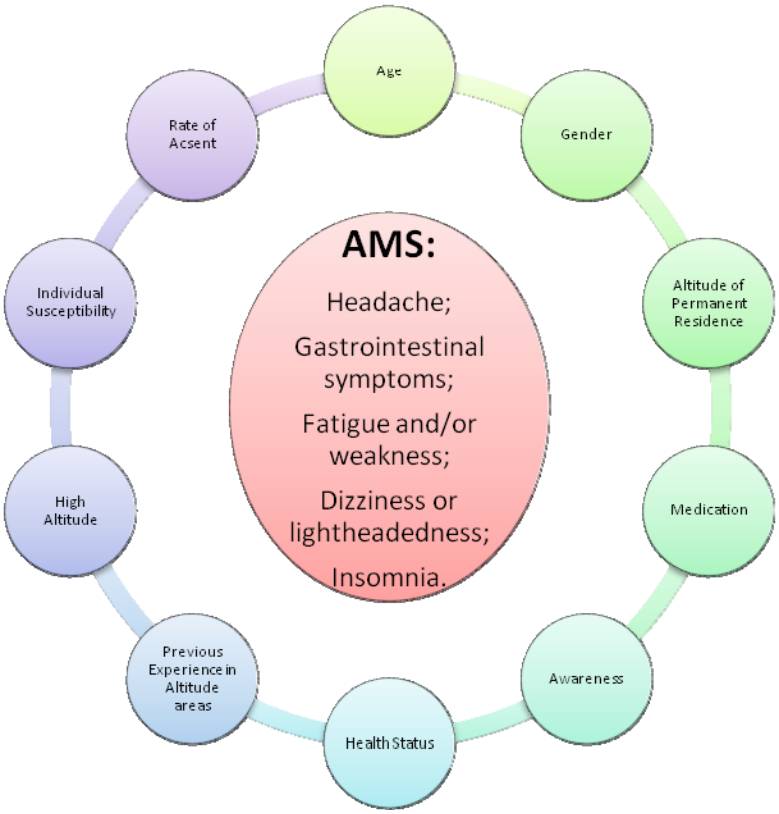

Figure 5. Determinants of acute mountain sickness prevalence (11;15;23) (20).

Altitude, way and rate of ascent

Based on the studies among Alpine mountaineers (15), in visitors to the Rocky Mountain (11), in trekkers in Nepal (23), and in the army in Tibet (20), prevalence of AMS increases progressively with altitude and with a fast rate in both active ascent, such as by foot or bicycle, s well as passive ascent such as by air, car or train (Table 5). Differences in prevalence between studies may be explained by varying definitions of AMS, differences in study population, mode of ascent, altitude, and activity level at altitude (Table 5).

Pre-acclimation

Altitude acclimatization indicates the process of adjusting to decreasing oxygen levels at higher elevations, in order to reduce the risk of altitude sickness (47). Previous experiences at

Table 5. Prevalence of Acute Mountain Sickness (AMS) in different studies

Study population	Age (years and range)	n	Definition of AMS	Altitude (m)	Transportation	Prevalence of AMS (%)	Prevalence of HACE or HAPE(%)	Research site (latitude N°)	Study design	Response rate (%)	Medication	Ref.
Conference Attendees (general tourist)	44(16-87)	3158	LLSS ≥3 symptoms	1828-2134	Car in 1 or 2 days	18	NG	Colorado, USA (37)	Cross-sectional study convenience sample questionnaire in English	75	Acetazolamide	*(11)*
		?		2135-2743		22						
		?		2744-2957		27						
Mountaineers	NG	47	LLSS >2 symptoms	2850	Within 1 or more days By foot +passive	9	0.05	Swiss Alps (46)	interview and clinical examination Questionnaire in German & Italian	NG	NG	*(15)*
		128		3050		13						
		82		3650		34						
		209		4559		52						
Trekkers	34(18-70)	20	Headache and a LLS≥ 3	2500-3000	By foot	0	0.7	Nepali Himalaya (27)	Prospective, observational study, convenience sample Interview in English	NG	Acetazolamide	*(48)*
		18		3000-3500		10						
		18		3500-4000		10						
		17		4000-4500		15						
		17		4500-5000		51						
		23		>5000		34						
Mountaineers or Tourists	34.7±10.4	79	Headache, an additional symptom and a LLS≥ 4	3454	By foot	38	NG	Eastern Aples (46)	Prospective, observational study, Questionnaire in German,English,French	about 60	NG	*(17)*
	36.8±11.6	83		3817		34		Western Aples (46)				
Trekkers	NG	1066	LLSS (LLS≥3)	3952	by foot (stepwise ascent)	36	1/1066	Mt. Jade in Taiwan (23)	Prospective, observational study (1 year) Questionnaire	NG	Acetazolamide Rhodiola	*(21)*
New Army	18 (17-20)	3605	Chinese standard	3600	By airplane	57.2	1.9%	Tibet	Cross-sectional study questionnaire in Chinese	99.36	NG	*(20)*
Trekkers	38	353	ESQ	5400	By foot within 2-3days	63	3/530	Thorong pass in Nepal (27)	Prospective study, Questionnaires	70	Aspirin, Paracetamol	*(23)*
Tourists	45.3(12-93)	116	LLSS ≥3 symptoms	3740	By airplane	84	NG	Shyangboche in Nepal (27)	Cross-sectional study, Questionnaire in English& Japanese	1000	21 took Acetazolamide	*(49)*
		38			By foot	61						
		2203				50.8				60		

LLSS: Lake Louise score system; LLS: Lake Louise score; n: the number of the people involved in the study; HACE: high-altitude cerebral edema; HAPE: high-altitude pulmonary edema; m: meters; NG: not given

high altitude prevent or ameliorate AMS symptoms on re-ascent after return to sea level (3;10;25).

Age

In adults, there is a decrease in AMS with increasing age (above 40) as reported widely among Himalayan trekkers (34), conference attendees (11), and mountaineers (15). It seems that older people may be somewhat protected from AMS, but the reason for this is not yet known. In contrast to this finding, the current perception is that older people are more sensitive to symptoms of AMS and thus more careful about their health and less frequently ascend to high altitude areas.

Gender

Men and women seem to suffer from AMS with comparable frequency and severity. The incidence in men and women trekkers at Everest Base Camp is 51% *vs.*53% respectively (15). However, it has been reported that women have a slightly greater risk for AMS when pregnant or taking oral contraceptives (10). In contrast, one study shows AMS to be significantly more frequent in males than in females, 27.9% *vs.*23.6% at intermediate altitude (11) and 69% *vs.* 57% at 5400 m above sea level (23). In general, most articles indicate that there are most likely no substantial gender differences in susceptibility to AMS, but the conclusion is different in different study sites and with different study designs.

Diseases and health behavior

A good state of health is recommended before ascent high altitude areas (22). People with obesity, severe hypertension, lung diseases (11), severe heart disease and upper gastrointestinal tract bleeding are advised not to travel to high altitudes (22). Asthmatic subjects, however, are considered to be better at high altitudes (10;22). Getting a cold is regarded as dangerous when entering high altitude, as it will increase the risk of AMS (50;51). Three studies reported no effect of cigarette smoking (10;11;23) on the prevalence of AMS.

Individual susceptibility

Individual susceptibility to AMS is reported and discussed broadly (6;10;11), but it is still not clear which particular physiological or pathophysiological features are associated with an increased individual susceptibility to AMS. See more about individual susceptibility in the section below.

4) Pathophysiology of AMS

The exact pathophysiological process that causes AMS is still unclear, although signs and symptoms of AMS and HACE point to a process in the central nervous system as the target organ for the illnesses. AMS is caused by an early stage of brain swelling, which at a later stage will cause HACE (7;32;52-57).

A pathophysiological model of AMS and HACE, frequently reported in the literature (56;58;59), is based on reaction to hypoxia. Hypoxia occurs often among unacclimatized arrivals to high altitude. Hypoxemia refers to a lowered oxygen level in the blood, and AMS will easily develop (3). Hypoxemia causes brain edema and neuro-humoral and hemodynamic reactions that finally lead to a rise in the cerebral blood flow, altered permeability of the blood-brain barrier (BBB), and cerebral edema, as indicated in Figure 6. These changes result in brain swelling and raised intracranial pressure. According Hackett (58) and Roach (59), AMS may occur in persons who have inadequate cerebrospinal capacity to buffer the brain swelling; people with a larger ratio of cranial cerebrospinal fluid to the brain volume are better able to compensate for the swelling by displacement of cerebrospinal fluid. This hypothesis could explain the individual susceptibility of AMS, but it still remains speculative.

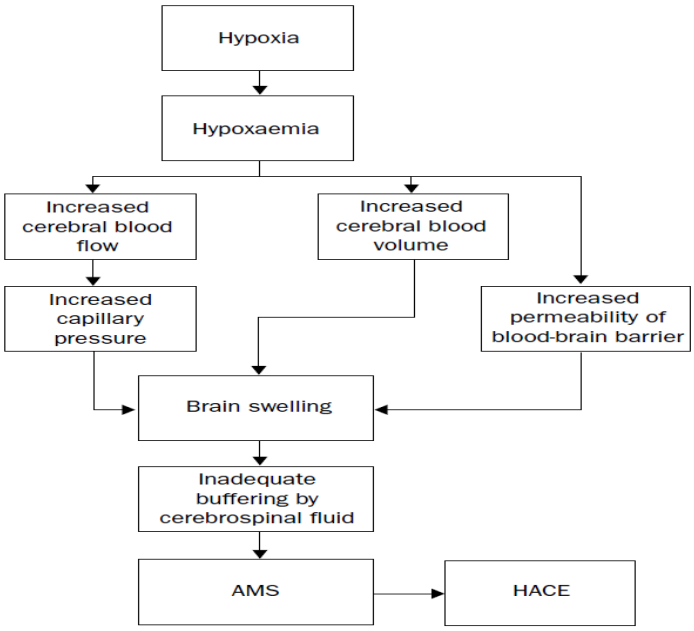

Figure 6. Proposed pathophysiology of AMS and HACE (*Adapted from* Basnyat B., Murdoch DR. High-altitude illness (4))

Other possible pathophysiologies of AMS, HACE and HAPE are also mentioned in older literatures (54;60-62), but all of them are still hypothetical. Even MRI findings among patients with HACE show changes are consistent with vasogenic edema (5;55), which has also been shown in animal studies (4)**.** More research on the AMS mechanism should be done.

5) Prevention of AMS

Acclimatization serves to increase the delivery of oxygen to tissue, which is best achieved by gradual ascent (3;25). An ideal ascent rate is difficult to give and varies from person to person (4). Slower ascent may be necessary for some people, but not to all. A good recommendation about acclimatization and rates of ascent is the following: above 3000 m an increase in sleeping altitude should not extend 300 to 600 m per day and a day's rest is recommendable for every 1000 meters of elevation gained; flying or driving directly to high altitudes should be avoided if possible. If symptoms of AMS occur and the state of health deteriorate, one should delay further the ascent or descend promptly. As AMS is worse during night (3;25), it is also advised to climb high but sleep low.

Generally, acclimatization takes one to three days, but the rate varies for different people. Full acclimatization takes considerably longer time. No reliable predictors for easy acclimatization exist, except that people tend to be consistent in how well they acclimatize on different trips.

In addition, in terms of existing individual susceptibility to AMS, a previous experience of AMS is the strongest indicator that it will be repeated during subsequent exposures to similar altitude at a similar ascent rate (4;32).

Drug treatment before ascent may also be used as prophylaxis against AMS. Acetazolamide, Dexamethasone and others have been recommended for people susceptible to AMS in the western world as have some traditional Chinese and Tibetan medicines which are used a lot by Chinese visitor to Tibet. However, the effectiveness and required doses of Acetazolamide and other medicine are still not very clear (63-66). Rhodiola Rosea (*Hong Jing Tian "红景天"* in Chinese and "*Solo Marpo"* in Tibetan) capsule is one of most popular traditional Chinese or Tibetan medicines to prevent AMS, even if in Tibetan medicine Solo Marpo has in the past not used on its own, but only in compounds. *Solo Marpo* positive effect in the prevention of AMS or in improving the AMS symptoms is confirmed in several studies (67-69).

6) Treatment of AMS

Generally, treatment of AMS depends upon the severity of the symptom and, especially in mild cases, on patients' preference. Mild cases can be treated conservatively, which means that the patients should avoid further ascent, limit physical activity, rest more and take adequate fluid (9) as well as that he or she should abstain from all alcoholic beverage and shall seek further care if symptoms get worse. Moderate to severe symptoms may require medication for symptomatic treatment such as against headache, nausea and vomiting, possibly supplemental oxygen and occasionally require descent. Because of the danger of exacerbating hypoxemia during sleep, avoidance of sleeping medication is suggested (70).

Descent is always an effective treatment for AMS and in the wilderness; a portable hyperbaric bag may be used as an alternative to descent. Supplemental oxygen will certainly reduce hypoxia.

AMS patients must be carefully monitored for any sign about whether the illness is progressing. If symptoms worsen patients need to descend immediately. Subtle changes such as irritability, lethargy, diminished performance, and shortness of breath at rest should also be taken as signs that the patient might be progressing towards HACE or HAPE.

3. Aim and research objectives

The main *aim* of the current research is to estimate the prevalence of AMS among tourists above fifteen years old in high altitude.

Specific objectives

1. To estimate the prevalence of acute mountain sickness among tourists above fifteen years in Lhasa, Tibet.
2. To estimate the prevalence of acute mountain sickness in subgroups of the tourist population by risk or protective factors reported in the previous studies.

CHAPTER III POPULATION AND METHODS

1. Design

A cross-sectional study was conducted among tourists above fifteen years of who stayed in selected hotels in Lhasa, during the research period from 2nd of June to 31st of October 2010.

2. Population

The study population were tourists above fifteen years old in Lhasa.

The definition of a 'tourist' varies according to context. According to the United Nation World Tourism Organization in 1995, tourists are people who "travel to and stay in places outside their usual environment for more than twenty-four hours and not more than one consecutive year for leisure, business and other purposes not related to the exercise of an activity remunerated from within the place visited" (71). In our study, we included the following question from the questionnaire: "Do you consider yourself to be a tourist on the present travel to Lhasa," in order to distinguish between tourists and other travelers.

3. Recruitment

The current study was carried out at hotels in the Cheng Guan District in the center of Lhasa, where most hotels are located (Figure 7). All selected hotels where the research was carried out are located in the main tourist zone in Lhasa.

We used a simple cluster random method to select the sample. We randomly selected nine hotels from high, middle and low standards, where we then we inviting tourists who stayed there to particpate.

Based on general hotel ratings we defined a high-level hotel as having a minimum of four-stars; mid-level hotel as distinguished by two and three stars and low-level hotel as featuring one-star.

Figure 7. Map of Lhasa city with research hotels-marked in yellow. (*Adapted from* Tibet travel information: http://www.tibettravel.info/images/map/map-of-lhasa-x.jpg)

Since there are more rooms in high-level hotel and fewer rooms in low-level hotels, we randomly selected more low level hotels than high level hotels from the official list of hotels in Lhas. Of a high-level hotels, the Lhasa Manasarovar Hotel and the Jodan Secret Hotel (two) were selected from the official list of hotels in Lhasa, of mid-level hotels the Lhasa Gorkha Hotel, the Yak Hotel and the New Mandala Hotel (three) were selected and of low level hotels, the Lhasa International Youth Hostel, the Dongcuo International Youth Hostel, the Cool Yak Hotel and Old Mandala Hotel (four) were chosen.

The Jordan Secret Hotel refused to participate immediately after we invited them. After one month of the data collection period, the three-star Yak Hotel and one-star Dongcuo International Youth Hostel withdrew from the project and we did not receive questionnaires from the high-level Lhasa Manasarovar Hotel. Thus, from 2nd of July 2010 onwards, the study was conducted in the remaining five hotels. (See Figure 8.)

The criteria for inclusion and exclusion for the study were the following:

1) **Inclusion criteria**

- Check in at the selected hotels during the study period;
- Ability to read and understand a Chinese or English version of the questionnaire;
- Age above fifteen years;

2) **Exclusion criteria**

- Travelling to Tibet as non-tourist.

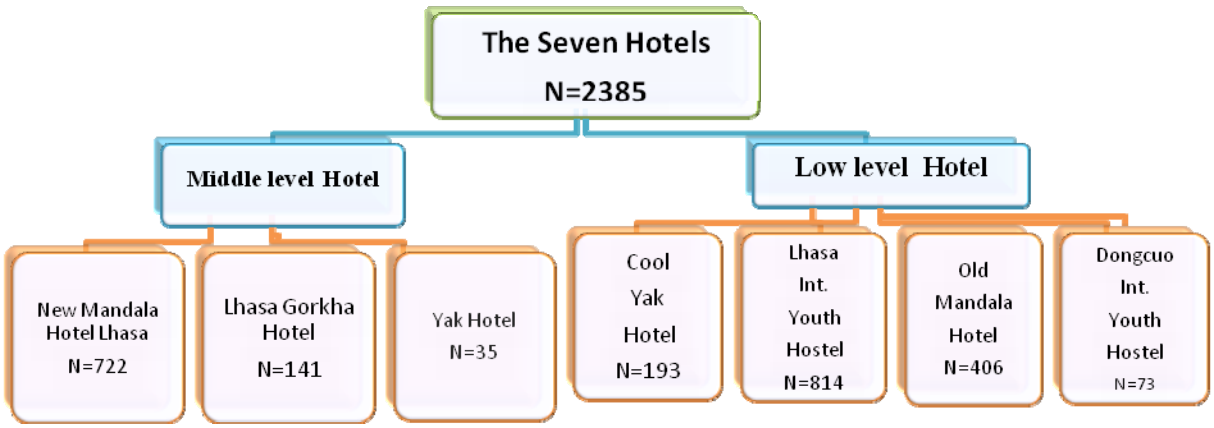

Figure 8. Final sample and the number of questionnaires received from the hotels from June 2 to October 31, 2010. (Int. Youth Hostel: International Youth Hostel.)

4. Data collection

During the research period, we distributed 4000 questionnaires to eligible participant who stayed in the randomly selected hotels.

1) The questionnaire

We developed a questionnaire for the study, which followed the Lake Louise Scoring System (LLSS) which has been described earlier in this thesis. The questionnaire was tested in a pilot study in 2008 and the a revised version version was developed based on the experience gained during the pilot (24).

The questionnaire has two pages, consisting of a total of 32 questions, which had been divided into eight main categories boxes. Box C of the questionnaire includes the Lake Louise questions on AMS (5 questions) (For details, see Appendix 1). The remaining questions provide general background information (age, gender, education, nationality, altitude of permanent residence, height, weight), way of transport to Lhasa, previous experience at high altitude, help seek due to AMS symptoms, health status, smoking habits, utilization of counter-high altitude sickness medicine, awareness of altitude sickness, activity after arriving in Lhasa and earlier exposure to altitude.

The questionnaire on AMS itself in our questionnaire is identical to the one originally devised by the LLSS in English. We also applied a Chinese translated version for the Chinese speaking participants in the study. We translated the original English version into Chinese, and back translated to English to check for translation errors. Our Chinese translation was also adjusted to the original Chinese translation made by the Chinese Medical Association and Wu Tianyi from the National Key Laboratory of High Altitude Medicine in China, Qinghai University.

2) Training of field workers

We recruited eight fourth-year grade students from Tibet University Medical College (TUMC) and one to two receptionists from each hotel to assist the research.

Half-day training was given to all hotel receptionists, regarding how to distribute and collect questionnaires and how to record them in the registration book. The training took place at Tibet University Medical College.

Half-day training was also given to all student research assistants, regarding the research purpose and the questionnaire distribution and data collection procedure. All students were Tibetans, capable of speaking and writing both Tibetan and Chinese, and with a background in medical training covering basic research methods. A teacher from TUMC supervised them closely in how to distribute and collect questionnaires in hotels during the first week, and then more sporadic supervised them during the first month.

Labasangzhu, the main researcher of the study, followed the students and the teacher during the last week of June, and then took over the work from 2nd of July to end of October, 2010.

3) Procedure for the distribution of questionnaires

The receptionists we have trained distributed the questionnaires to all tourists in their hotels. The distribution procedure (for details, see Appendix 4) depended on the length of the guests' stay in the hotel:

- If tourists planned to stay four nights or more, the questionnaire was delivered the third night after arrival.
- If tourists planned to stay two or three nights, the questionnaire was delivered on the day before they checked out.
- If tourists planned to stay only one night, the questionnaire was delivered at check-in time.
- If tourists, for any reason, stayed shorter than initially planned, then it was attempted to make them hand in the questionnaire before they left.

4) Collection of questionnaires

Good rapport was built between the main researcher and his research assistants. Feedback about the research was directly given to researcher by call or face-to-face communication.

Empty questionnaires, both English and Chinese versions, were sent to hotels once a week and kept at reception. Completed questionnaires were collected every day and checked for completeness and errors. The number of completed questionnaire was checked against the number of registered questionnaires.

5) Payment for data collection

All research assistants including hotel receptionists and students were paid for their work. Three Chinese Yuan (CNY) were paid to the receptionists for each questionnaire collected in addition to a basic allowance per month, which was CNY 500 at high level hotel, CNY 300 at mid-level hotels and CNY 200 at low level hotel. All students were paid CNY 200 per student, plus a transportation fee and expenses for phone call for their work were paid for the period between 2nd of June to 31st of October 2010.

5. Data entering

A codebook was created and data from the questionnaire was entered into Statistical Package for Social Science (SPSS 15.0 version IBM, Chicago, IL, USA) by the author and the author's colleague in December 2010.

Data was cleaned under the guidelines of the Predictive Analytics Software statistics 18.0 (PASW18.0) from 11th of January to 15th of February 2011. The data was checked for double recordings and odd values.

6. Study variables

AMS was the main variable under study. AMS according to the LLSS is based on five different symptoms, which include the following:

a. Headache
b. Gastrointestinal symptoms
c. Fatigue and/or weakness
d. Dizziness or lightheadedness
e. Difficulty of sleeping or insomnia

Each symptom was ranked from 0 to 3 based on intensity levels of absence of symptoms, mild, moderate and severe symptoms.

In the present study, the Lake Louise Scoring System (LLSS) was used. The definition (Appendix 1) of AMS mainly used was as follow:

i. the presence of headache in an unacclimatized person who has recently arrived at Lhasa (3649 m), Tibet;

ii. *Plus* the presence of one or more of the following symptoms: gastrointestinal symptoms, fatigue and/or weakness, dizziness/light-headedness, insomnia and,

iii. Lake Louise scores at least three (≥3).

To be able to compare with reported prevalence of AMS from other studies, we also applied the following two definitions:

a. AMS defined as Lake Louise scores at least three (≥3), independent of having a headache or not.

b. AMS defined as presence of headache plus one of the other symptoms and a Lake Louise score of at least four (≥4).

We estimated the prevalence of AMS in subgroups of the population. The following variables were used to define the subgroup, as shown in Table 7.

English and Chinese language questionnaires were available in the present study. The prevalence of AMS was presented separately for participants answering the English and Chinese version of the questionnaire.

Age was reported in years converted into a categorical variable (15 to 19 years: adolescence; 20 to 40 years: young adult; 41 to 60 years; middle aged; more than 60 (>60) years: elderly).

Education level was categorized into “some high school education(attended some high school but did not graduate)” , “high school education (graduate with high school diploma)” , “some college education (attended some college but did not graduate)” , and “university or higher education” .

We used two categories of residential altitude: 2000 meters or higher (>6500ft) and below 2000 meters (<6500ft).

Weight was reported in kilograms or pounds and height in centimeters, feet, and inches. The reported information was converted to kilograms for weight and centimeter for height. BMI was calculated and categorized according to the World Health Organization (WHO) definition of Body Mass Index (BMI) (kg/m^2) (Table 6).

Table 6. The international classification of adult underweight, overweight and obesity according to body mass index (BMI)

Classification	Principal cut-off points of BMI(kg/m2)
Underweight	<18.50
Normal range	18.50 - 24.99
Overweight	≥25.00
Obese	≥30.00

Source: Adapted from WHO, 1995, WHO, 2000 and WHO 2004.

Three options were listed in the questionnaire for the way of transport used by the tourists when arriving in Lhasa: airplane, train and car or bus. An extra category had to be added as there were tourists that reported arrival by bike or by foot.

General state of health means the state of health before arriving Lhasa. This was a question requiring self-report with answers such as poor, not very good, good or very good.

Health problem was taken to mean whether the participant had been diagnose with a disease by a doctor.

Whether the subject took medication to prevent AMS was an 'yes or no'-question followed by the question "What kinds of medicine had been taken?"

Table 7. Operationalization of variables

Variable	Scale	Coding	Remark
Headache;	Categorical	0=No headache 1=Mild headache 2=Moderate headache 3=Severe headache, incapacitating	
Gastrointestinal symptoms;	Categorical	0=No gastrointestinal symptoms 1=poor appetite or nausea 2=Moderate nausea or vomiting 3=Severe nausea or vomiting ,incapacitating	
Fatigue and/or weakness;	Categorical	0=No tired or weak 1=Mild fatigue/weakness 2=Moderate fatigue/weakness 3=Severe fatigue/weakness, incapacitating	
Dizziness or lightheadedness;	Categorical	0=Not dizzy 1=Mild dizziness 2=Moderate dizziness 3=Severe dizziness, incapacitating	
Difficulty sleeping	Categorical	0=Sleeping as well as usual 1=do not sleeping as well as usual 2=Woke us many times, poor night's sleep 3=Could not sleep at all	
Questionnaire Language	Categorical	1=English 2=Chinese	
Age	Continuous	>=15 years	Converted into categorical variable as Age group: 1=15 to 19; 2=20 to 39; 3=40 to 60; 4= more than 60.
Gender	Categorical	0=female 1=male	
Nationality	Categorical	1=Chinese; 2=American; 3=Spanish; …… 48=Latvian	
Level of education	Categorical	1=<some high school 2= high school 3=some college 4>=University/master	some high school/college education(attended some high school/college but did not graduate)
Altitude of permanent residence	Categorical	1=2000 meters or higer (>6500ft) 2=< 2000 meters (<6500ft)	
Weight	Continuous	Self-reported weight in Kilograms /pounds	Converted into categorical with body mass index(BMI)
Height	Continuous	Self-reported height in Centimeters /feet/inches	
Tourist	Categorical	0=no 1=yes	
Date of arriving	date	Day/month/year	
Transportation to Lhasa	Categorical	1=by airplane 2= by train 3=by car/bus 4=by bike 5=by foot	
Previous experience in high altitude area	Categorical	0=no 1=yes	
Self-reported reason for AMS symptoms	Categorical	0=no 1=yes	Food and drink/high altitude/other
If get help in Lhasa	Categorical	0=no 1=yes	Doctor/nurse at hotel and to hospital
Diagnose AMS	Categorical	0=no 1=yes 2= I do not know	
Health status	Categorical	1=poor 2=not very good 3=good 4=very good	
Health problem	Categorical	0=no 1=yes	Diabetes/hypertension/Cardiovascular diseases/asthma
Smoking habits	Categorical	0=no 1=yes	
Pregnant	Categorical	0=no 1=yes	
Contraception	Categorical	0=no 1=yes	
Medicine to prevent AMS	Categorical	0=no 1=yes	
Fluid intake 24 hour before and after in Lhasa	Categorical	1=Less than normal 2=Normal 3=More than Normal	
Pain-reliving medicine use	Categorical	0=no 1=yes	
Awareness of AMS before arriving in Lhasa	Categorical	0=no 1=yes	
Physical exercise after in Lhasa	Categorical	0=no 1=yes	
Experience of AM before this time in Lhasa	Categorical	0=no 1=yes 2=never been at high	

7. Statistical methods

The prevalence of AMS was estimated among a the total sample and in a subset of the sample where we had a high response rate (which means in two hotels during a limited time period) (Table 8 and 11).

The subgroups set according to the risk factors or protective factors report in previous study.

Chi-square (χ^2) tests were applied for comparing differences in prevalence between subgroups of the population.

Level of statistical significance was set to $p \leq 0.05$ and/or 95 percent confidence interval (95%CI).

Predictive Analytics SoftWare 18.0 was used for statistical analysis.

8. Ethical considerations

All research process strictly followed the World Medicine Association Declaration of Helsinki the 59th General Assembly in 2008 (72).

Participation was voluntary and anonymous with no name or identity written on any research documents.

1) Benefits to participants in the study

Participation in the study may not have benefited the participants directly, but the study has probably raised the tourists' awareness about AMS. It may lead to future better understanding of AMS, which will have an overall positive effect on travelers to high altitude areas in the world.

2) Risks

This study posed no known risk to its participants. The information collected was considered only marginally sensitive and participants were informed of their right to choose not to answer any questions that may have made them uncomfortable. There was no risk of physical injury in the participation of the survey.

3) Confidentiality

The questionnaire was entirely anonymous and there was no physical contact between researcher and subjects. Therefore the confidentiality of subjects was guaranteed to a great extent.

4) Ethical approval

Prior to data collection, in May 2010, the study protocol was submitted to the Norwegian National Committee for Medical and Health Research Ethics to receive official ethical clearance approval from their committee. However, the committee found the study unnecessary to undergo evaluation.

We attached information about the study on each questionnaire, and participants were asked to read it carefully before deciding whether to participate or not.

9. Communication of results

The present thesis will be published through the DUO system of the University of Oslo (UiO), Norway. At a later stage, the aim is try to publish the findings in international peer-reviewed journals.

The author and colleagues plan to present a summary of the study to the health and tourism authorities in Lhasa, and will present the study's findings at scientific meetings and conferences.

CHAPTER IV STUDY RESULTS

1. Response rate

Altogether 4000 questionnaires were distributed and 2385 were returned, which means a return rate of 60%. Among those that were returned, 106 people stated they refused to participant and 104 of these also stated their reason. The lack of understanding either Chinese or English and time limitation were main reasons. Nine questionnaires were considered unreliable because they featured the same handwriting as another questionnaire; 30 questionnaires were filled in incompletely; ten were answered by tourists less than fifteen years of age and 27 were answered by non-tourists. Therefore, 2203 questionnaires out of 4000 were used in data analysis, giving the study a response rate of 55.1%.

The response rate varied between hotels and over the time period. The response rate during July and August in the New Mandala Hotel and between the 18th of August and the 29th of October in the Old Mandala Hotel was 86% and 73% respectively (Table 8). The total response rate in the two hotels' reached to 79%.

Table 8. Response rate in the Old Mandala Hotel and the New Mandala Hotel in Lhasa

Hotel	*Time period*	*Guests in Hotel**	*Distributed Questionnaires***	*Received Questionnaires****	*Response rate %*
Old Mandala Hotel	18 Aug-29 Oct	*642*	340	291	86
New Mandala Hotel	2 Jul-30Aug	---****	350	252	72
Total		*642+?*	690	543	79

* Number of guests who were registered on hotel register book.
** Number of questionnaires received from tourists.
***Number of questionnaires distributed to tourists.
**** Data are not available in from New Mandala Hotel.

The results of this study will be presented in the following order below: Demographic characteristics, Prevalence of AMS, and Prevalence of AMS in subgroups.

2. Socio-demographic characteristics

Socio-demographic characteristics of gender are presented in Table 9.

Participants ranged in age from 15 to 81 years and the mean age was 37.2 (36.9 for females and 37.7 for males). Most participants (61.1%) were in the 20 to 40 age group, and only 3.9% in the age group 15 to 19. 65.5% of the participants had obtained university or higher education, while only 4% had some high school education but not graduated or they were still studying in high school. More than one third of participants stayed in middle level hotels and the remaining lived in low level hotels. Most of participants were low altitude dwellers, only 5% had residence at 2000 meters or higher areas. More than half of participants filled in English questionnaires.

Table 9. Socio-demographic characteristics among tourists above 15 years old in Lhasa

Characteristics	**Women,** N(%)*	**Men,** N(%)*	**Total,** N(%)*
Age group			
15-19	46 (4.1)	39 (3.6)	85 (3.9)
20-40	686 (61.7)	656 (60.5)	1342 (61.1)
41-60	274 (24.6)	270 (24.9)	544 (24.8)
Older than 60	106 (9.5)	119 (11.0)	225 (10.2)
Mean Age (years)	36.9	37.7	37.2
Education			
Some high school	47 (4.3)	44 (4.2)	91 (4.2)
High school	142 (13.0)	131 (12.4)	273 (12.7)
Some College	212 (19.4)	173 (16.4)	385 (18.0)
University or higher	689 (63.2)	705 (67.0)	1394 (65.5)
Hotel			
Middle Level Hotel	401 (36)	379 (35)	780 (35.5)
Low Level Hotel	713 (64)	703 (65)	1416 (64.5)
Language of questionnaire			
English	594 (53.4)	597 (55.1)	1191 (54.2)
Chinese	518 (46.6)	487 (44.9)	1005 (45.8)
Altitude of permanent residence/home			
2000 meter or higer (>6500ft)	48 (4.5)	65 (6.2)	113 (5.3)
Below 2000 meters(<6500ft)	1023 (95.5)	984 (93.8)	2007 (94.7)

* Number of participants (%).

Tourists from 48 different countries participated in the study and of which Chinese tourists were the largest group of participants numbering 1023 (46.9%), followed by 138 (6.3%)Dutch with, 126 (5.8%)the Americans, 106 (4.8%) the Germans, 82 (3.7%) the French, and 80 (3.7%) British. (See Figure 9).

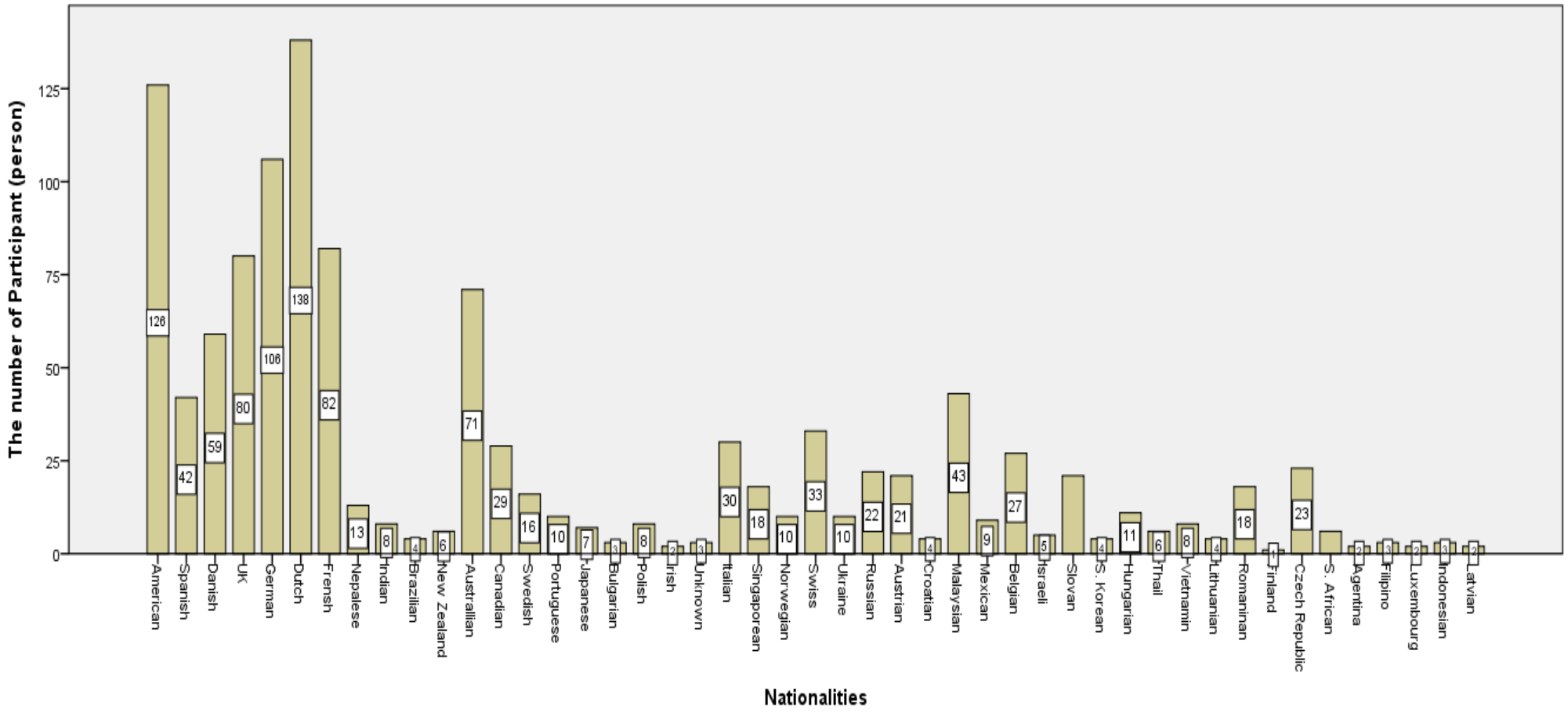

Figure 9. Number of participants and their nationalities

(1023 Chinese participants not included; Unknown: the name of the country is not on the world countries list.)

3. The Prevalence of AMS

In the total sample (n=2203), the prevalence of AMS was estimated to 50.8%, while in the subgroup of the two hotels (n=543) was 44% according to the Lake Louise scoring system (LLSS) AMS diagnosis standard (headache plus one of other symptoms and Lake Louise score (LLS)≥ 3) (Table 11).

Base on the AMS definition: headache plus one of other symptoms and LLS≥4, the prevalence dropped to 36.7% in the total sample and 35.2% in the two hotels sample (Table 11). This definition indentifies more severe cases.

Using the AMS definition LLS≥ 3, without requirement of headache being a symptom, the prevalence increased to 58.5% in the total sample and 53.1% in the two hotels sample.

The study did not aim at identifying cases with the more severe conditions HACE and HAPE, but based on personal communication with a doctor in the 'First TAR People's Hospital', at least two person from Lhasa Gorkha Hotel in August 2010 were urgently sent back to low-land by plane due to HACE or HAPE.

Table 10.Prevalence of acute mountain sickness (AMS) in tourists above 15 years of age in Lhasa, Tibet

AMS definition		The 2203 Sample (The Whole Sample)		The 543 Sample (The Two Hotels' Sample)	
		Responders	Prevalence% (95% CI)	Responders	Prevalence% (95% CI)
AMS LLS standard	**Yes**	**1107**	**50.8 (49–53)**	**239**	**44 (40– 48)**
(Headache is compulsory) **LLS*≥3**	No	1070	49.2	304	56
AMS LLS standard	**Yes**	**748**	**36.7 (34.6–38.8)**	**184**	**35.2 (31.1–39.3)**
(Headache is compulsory) **LLS* ≥4**	No	1288	63.3	399	64.8
AMS LLS*≥3	Yes	1224	58.5 (56–61)	286	53.1 (49–57)
(Headache is ***not*** compulsory)	No	867	41.8	253	46.9

* Lake Louise Score.

4. Symptoms of AMS

82% of participants reported symptoms of AMS in the total sample. The most common of the five AMS symptom was fatigue and/or weakness (66.8%), while the least common was gastrointestinal symptom (25.6%) . The symptom insomnia had the largest percentage of severe condition (3.4%) (Figure 11).

For almost half of the participants who suffered from AMS, the onset of symptoms occurred within the first twelve hours after arriving in Lhasa. 15.3% of the participants with AMS symptoms the onset of symptoms was between 12 and 24 hours; and 3.8% between 24 and 48 hours and after 2.8% after 48 hours. Moreover, 30.5% of participants suffered from the AMS symptoms before they reached hotels in Lhasa. Among them, 60.1% took train to Lhasa, 22.1% by air (including the road by car from airport to Lhasa), and in 17% by car or bus.

The results were similar in the two hotels sample regarding the symptoms of AMS.

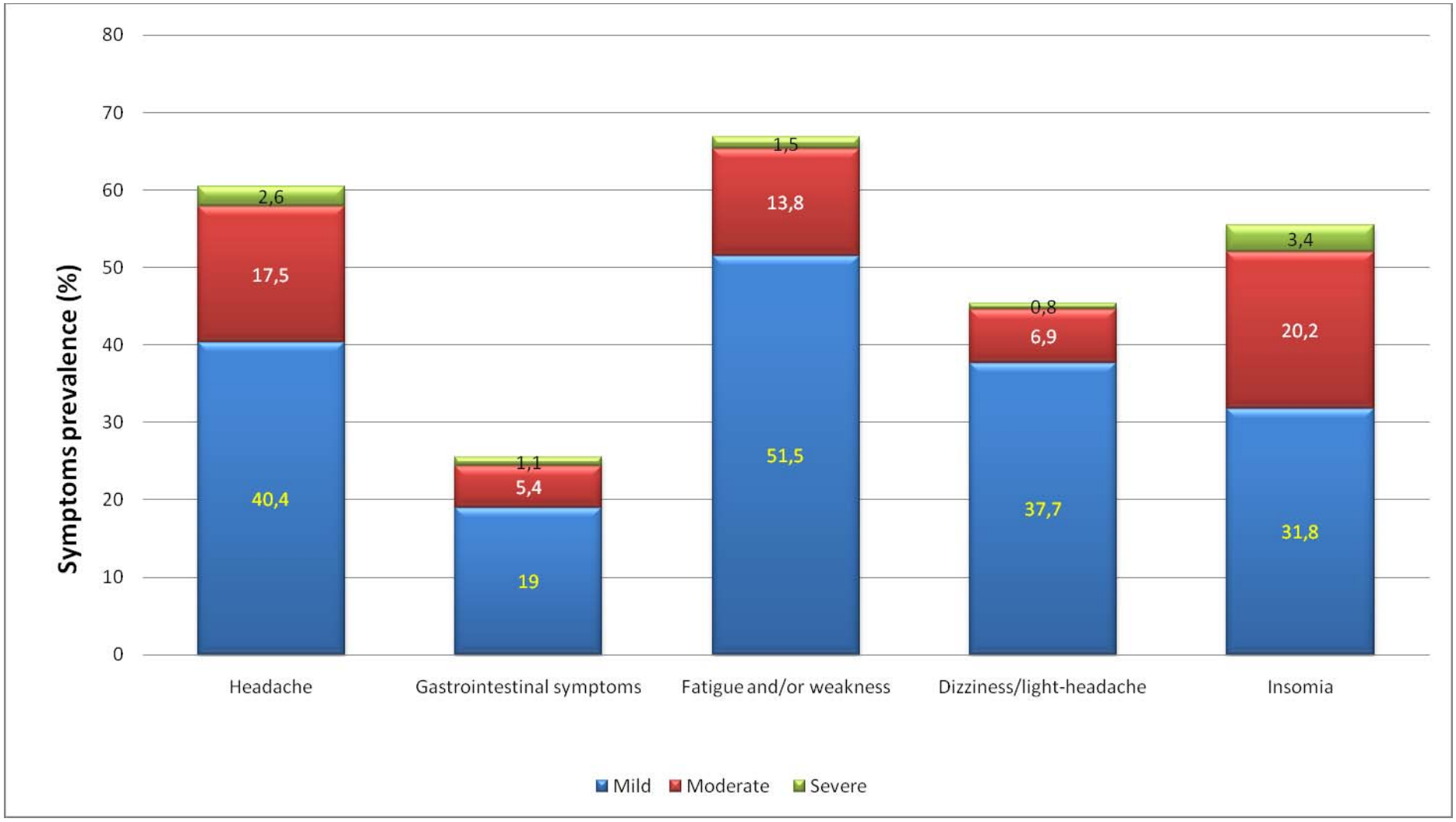

Figure 10. Symptoms prevalence (%) of acute mountain sickness in the total sample (n=2203)

5. Prevalence of AMS in subgroups of the population

In table 11, we present the prevalence of AMS in subgroups of the population.

The AMS prevalence among participants with previous experience at high altitudes was significantly lower than in those without previous experience.

The prevalence of AMS in people aged at 20 – 40 and 40 – 60 was significantly higher than in younger and elder age groups.

Men had significantly higher AMS prevalence (53.4%) as compared to women (48.4%).

AMS among participants who arrived to Lhasa by air was significantly more common than among those arrived more gradually by bus or car.

The AMS among participants with previous AMS symptoms experience were significantly higher than those have not suffered from AMS symptoms.

The prevalence of AMS among smokers were significantly lower than non-smokers ($p<0.05$).

The AMS prevalence differs across countries, but care should be taken due to low members for some of the countries, especially among these with high or low prevalence (Figure 11).

Table 11. Prevalence of AMS in subgroups of the population of tourists above 15 years old visiting Lhasa, Tibet 2010

Characteristics	Responders*	AMS***, n (%)***	*p* value
Questionnaire language			
English	1175	578 (49.2)	0.094
Chinese	1002	529 (52.8)	
Gender			
Male	1104	590 (53.4)	**0.019**
Female	1068	517 (48.4)	
Age group			
15-19	86	36 (41.9)	0.003
20-40	1334	703 (52.7)	
41-60	532	276 (51.9)	
Older than 60	225	92 (40.9)	
Education			
Some high school	90	44 (48.9)	0.641
High school	270	129 (47.8)	
Some College	380	195 (51.3)	
University or higher	1385	718 (51.8)	
Altitude of perminient residence			
Below 2000 m	1993	1024 (51.4)	0.077
2000m or higher	110	47 (42.7)	
Previous experience at high altitude			
Yes	553	206 (37.3)	**<0.001**
No	1611	894 (55.5)	
Hotel			
Middle Level Hotel	769	408 (53.1)	0.242
Low Level Hotel	1398	705 (63.3)	
Transportations to Lhasa			
By air	1023	557 (54.4)	**0.001**
By train	944	469 (49.7)	
By bus/car	190	75 (39.5)	**Cont.**

* Numbers of total respondents to those items.

** Acute Mountain Sickness.

*** Numbers of total respondents to those items and percentage.

$p < 0.05$;

Tabel 11 cont. Prevalence of AMS in subgroups of the population of tourists above 15 years old visiting Lhasa, Tibet 2010

Characteristics	Responders*	AMS***, n (%)***	*p* value
BMI classifacation			
Underweight	189	85 (45.0)	0.316
Normal	1430	745 (52.1)	
Overweight	392	197 (50.3)	
Obese	119	60 (50.4)	
Lung diseases			
Yes	36	22 (61.1)	0.24
No	2067	1059 (51.2)	
Asthma			
Yes	54	24 (44.4)	0.306
No	2045	1053 (51.5)	
Cardiovascular diseases			
Yes	26	14 (53.8)	0.787
No	2069	1059 (51.2)	
Hypertension			
Yes	113	55 (48.7)	0.997
No	1982	1017 (51.3)	
Diabeties mellitus			
Yes	30	14 (46.7)	0.605
No	2075	1067 (51.4)	
Smoker			
Yes	251	110 (43.8)	**0.013**
No	1847	964 (52.2)	
Preganancy			
Yes	8	4 (50)	0.884
No	1105	581 (52.6)	
Awareness			
Yes	1850	953 (51.5)	0.387
No	247	120 (48.6)	
Previous AMS symptoms			
Yes	589	302 (51.3)	**<0.0001**
No	1010	470 (46.5)	
Never been at high altitude	463	284 (61.3)	

* Numbers of total respondents to those items.

** Acute Mountain Sickness.

*** Numbers of total respondents to those items and percentage.

$p < 0.05$;

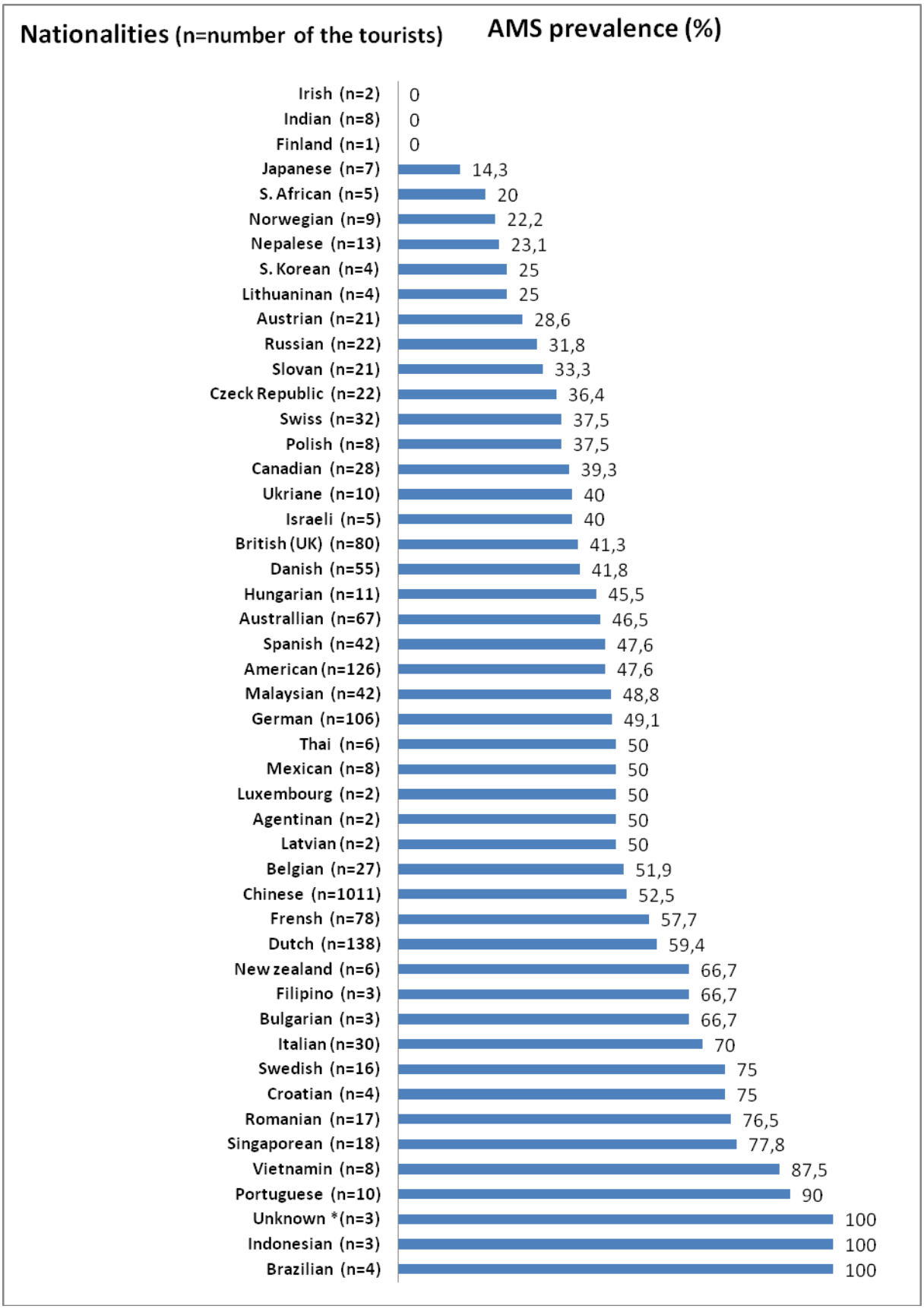

Figure 11. AMS prevalence in tourists according to country

(* The name of the country is not on the world countries list.)

6. Self-reported Causes of AMS Symptoms

Among the participants with the AMS symptoms (m=1572), 87.4% reported that the high altitude was the cause of the symptoms, and few (9.5%) believed that the bad quality of food or water in Lhasa was the cause of the symptoms, and the remaining of the participants thought that their symptoms were due lack of enough rest; weather; bad trip plan; jet lag; and poor hotel conditions such as hard mattress and noisy environment.

7. Awareness of AMS

88% of participants were aware of AMS before they travelled to Lhasa. The awareness was obtained through various information sources. Internet was the most used for obtaining AMS knowledge, followed by friends or colleagues or family members, travel guidebooks, travel agencies, doctors, other health personnel's and other (Figure12).

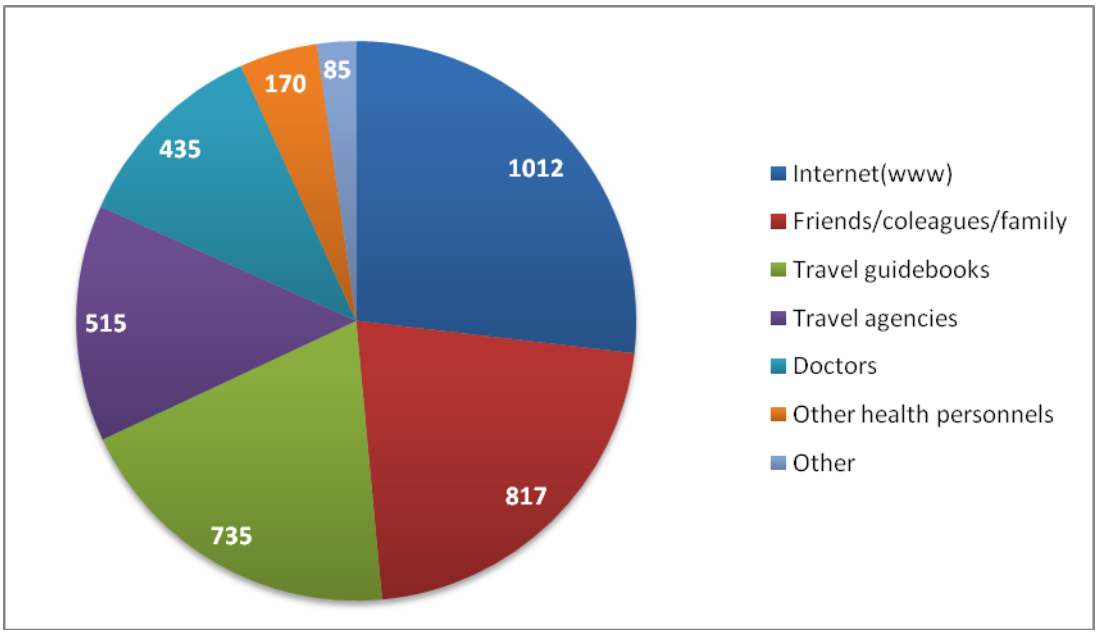

Figure 12. Source of AMS related information among the 2203 participants (numbers of people)

8. Prevention and Help Seeking

Almost half of the participants (n=965) took prophylactic medication to meet the high altitude. Among them, 25.3% used Acetazolamide or Diamox, 72.6% took other medicine and 2.1% took Stteroids or Nifedipin. 88.7% of whom took other medicines chose traditional Chinese

or Tibetan medicine Rhodiola (*Hong Jing Tian "红景天"* in Chinese and "*Solo Marpoin*" in Tibetan) capsule and alike. Slightly more than one quarter took pain-relieving medication during the first 48 hours after their arrival in Lhasa.

282 participants out of 1572 with AMS symptoms chose to seek help or advice during their stay in Lhasa. Among them, 20 (10.6%) received a visit by local doctor or nurse; 92 (32.6%) went to local hospitals or clinics; and 150 (53.2%) got help from others such as their tour companions or local Tibetan friends. Among those who had AMS symptoms, only 69 (4.7%) reported that they were diagnosed with AMS from a doctor or nurse.

CHAPTER V DISCUSSION AND CONCLUSION

1. Overview

For the first time this cross-sectional study has investigated the prevalence of acute mountain sickness (AMS) among domestic and international tourist groups in Lhasa based on the internationally accepted Lake Louise Scoring System (LLSS)-questionnaire.

The main findings of the present study are that AMS prevalence in in the study group in Lhasa was 50.8% based on the whole 2203 sample and 44% in the subgroups of the two hotel specific samples. More than 80% of participants suffered from at least one AMS symptom during their stay in Lhasa. Fatigue and/or weakness and headache were the two most commonly experienced symptoms.

2. Methodological consideration

Biases occur in almost all epidemiological studies and the present study is no exception in this regard. Bias is defined as a "deviation of results or inferences from the truth, or processes leading to such deviation" (73). Biases occur in the collection, analysis, interpretation, and/or review of data that can lead to conclusions that are systematically different from the truth (73). A biased study loses the validity of its result. It is difficult or even impossible to completely eliminate bias, but it is very important to minimize biases as much as possible with well-designed and well-conducted research. Moreover, it is crucial to check if results could be biased and then to draw conclusions accordingly.

In this methodological discussion, potential methodological problems in the study design, sample selection and information from participants will be discussed.

1) Study design

Following the aim of the present study, to estimate the prevalence of AMS, we designed a cross-sectional study.

In addition, to estimate the prevalence of diseases and determinants, a cross-sectional study examines the relationship between diseases and other variables of interest (73). Since one

cannot be sure if the factors or exposures preceded the health outcome in a cross-sectional study, the study can hardly offer evidence of causality (74). Nevertheless, a cross-sectional study estimates the prevalence of diseases (74), and that is the main aim of the present study was to investigate the prevalence of AMS.

To assess the AMS, the Lake Louise Score System (LLSS) has been used in the present study. Using LLSS makes it possible to compare our results with other studies because LLSS is internationally recognized and is the most used form to assess the occurrence of AMS (38;75;76). LLSS has been validated in numerous studie, the Lake Louise questionnaire is simple and effective (76;77), a short and simple questionnaire was considered to be important to get as many as possible of tourists in the hotels to paricipante in the study.

2) Selection problem

Selection problems here mainly refer to selection biases, which is an error because of systematic differences in characteristics between those who take part in the study and those who do not. Selection bias invalidates conclusions and generalization that might otherwise be drawn from the study (73).

One of the strengths of the present study is that the study hotels were randomly selected based on a hotel list given by the Chengguan District Tourism Bureau. However, we lack information from high-level hotels and it is not possible to know if this has led to bias in the results. Moreover, many tourists refused to participate due to various reasons such as time limitation, too long questionnaire, that could not understand an English and Chinese questionnaire or just because they have not suffered from AMS symptoms. In addition, it is likely that tourists with serious symptoms did not answer the questionnaire, which would lead to an underestimation of the prevalence of AMS.

In order to increase the response and, thus, to minimize the selection bias, the researcher stayed in the reception two to three hours every day to supervise research assistants' work.

Overall, selection bias may exist in the study; however, we did our best to avoid the bias, such as training research assistants and hotel receptionists and staying in hotels with hotel staffs.

We aimed at a high number of participants to allow for large variation in characteristics of tourists for subgroup analysis and to cover most of the tourist season. We distributed 4000 questionnaire from June to October and totally 2385 questionnaires returned (60%) and finally 2203 questionnaires analyzed, giving a response rate of 55.1%. The sample size is much larger than most previous similar studies, but it is known from previous studies that low

response rate may hamper prevalence estimates (78). We compared the prevalence estimate with a subset from 'two hotels' sample, including 543 participants with a response rate 79%.

The question that arises then is whether the total of 2203 with a response rate of 55.1% or the subset with a response rate of 79% shall better represent the total tourist population of Lhasa.

As we know surveys with high response rates yielded more accurate estimates than did surveys with lower response rates (79), the 543 sample, which were collected from one middle level hotel and one low level hotel should be better to estimate the prevalence. However, the sample is smaller than and perhaps not as representative as the total samples. The prevalence of AMS was 50.8% in the total sample and 445 in the subset. It is known from previous studies that non-response in higher among individuals with health problems (78), thus, we have an opposite situation in the present study. Based on our findings we could say that the prevalence of AMS among tourists in Lhasa is high, and between 44–50.8% and it is not known if it is an overestimate or underestimate.

3) Information problems

Information error could result in incorrect prevalence estimates (80). If the criteria for AMS are not valid in a way that if either systematically overestimate or underestimate symptoms of AMS. Also there will be incorrect estimate if there is a symmetric allocation of those with AMS by subgroups we were comparing.

Questionnaire was the tool to collect data in this study. Generally, the information on the questionnaire was straightforward and easy to understand. A pilot study was done to ensure that the questionnaire was correct illustrated and Chinese questionnaire was back translated into English and adjusted by the Chinese version previously used by National Key Laboratory of High Altitude Medicine in China.

One potential problems could be that tourists not really good in English or Chinese may have misunderstood questions. Although it is a large variation in AMS prevalence between nationalities of the tourists, such errors should not be symmetrically, and, thus, not affect the prevalence estimates.

We used self-reported symptoms rather than objective clinical examination or diagnostic test to obtain data on AMS. Most symptoms of AMS are not very specific, whereas some are common after a long time travel and accommodation changes. This error may have led to an overestimates of AMS in the present study.

In this study, the questionnaires were answered a short time after the subject's exposure at high altitude areas; therefore, the recall bias could be minimal. Interview bias may exist due to our hotel receptionists. Because some receptionists may have preferred to deliver questionnaire to healthy and easy-going guests and avoid disturbing to guests with poor health condition during their stay in the hotel, leading to underestimation of AMS. However, it is difficult to know if this source of bias was significantly, as we have trained receptionists to best possible practice.

3. Discussion of results

1) The prevalence of AMS

A total of 50.8% of tourists in Lhasa developed AMS based on the total sample, when defined as headache plus an additional symptom and LLS $\geq$ 3. The AMS prevalence in the Old Mandala Hotel and New Mandala Hotel in different time periods with 79% response rate amounted to 44% according to same diagnostic criteria. If 21% of guest who did not participate in the research developed AMS, then the prevalence would increase to 56%, alternatively, if all the 21% were free of sickness, the prevalence would drop to 35%.

The AMS prevalence in the current study was much lower than the prevalence of 84% noted by Murdoch (1995) (49) among tourists flying directly to 3740 meters and sleeping at 3860 meters altitude area. The difference in prevalence might be a result of increasing awareness of altitude-related illness among tourists as the study of Murdoch was conducted more than 15 years ago. Another reason could be from using the different modes of flight in different studies: civil airplanes with pressurization were used to Lhasa, but helicopters were used to Shyangboche Hotel in Nepal Himalayas (49).

Based on the same AMS definition: headache, an additional symptom and a Lake Louise scores at least four, the prevalence is quite similar among tourists in Lhasa (36.7% in the total sample and 35.2% in the two hotels' Sample) and mountaineer and tourists in Eastern (38%) and Western (34%) Alps (16;17;69). Moreover, these two studies had a similar altitude with Lhasa and a similar response rate (Table 5).

On other hand, though using different AMS definition, except for the study done in Nepal by Vardy and his colleagues (48), in most studies, the prevalence of AMS ranged from 34% to

57.2% at the altitude of 3000 to 4000 meters (14-17;20;22;76) (Table 5). This is quite similar to the findings of the present study.

2) The prevalence in subgroups

We support findings for several previous studies which reported that rapid ascent is a risk factor for developing of AMS (10;32;60). In this study we found that the prevalence of AMS was significantly higher among the tourists who flew or travel by train to Lhasa as compared with those who went by bus or car. Stepwise ascent is strongly recommended for when travelling to high altitude, but it is not very convenient to go by car or bus to Lhasa.

Although individual susceptibility as risk factors to AMS is reported and discussed widely (6;10;11), the mechanism is still unknown. People who have a previous experience of AMS symptoms should be careful when they re-enter high altitude areas. In the present study, we found that the prevalence among tourists with prior AMS episodes had significantly higher AMS than those without high altitude experience.

In adults, a decrease in AMS with increasing age (above 40) is reported among Himalayan trekkers (34), conference attendees (11), mountaineers (15). It seems that older persons may be less susceptible from AMS, but the reason is not known yet. The perception is that older people are more sensitive about symptoms of AMS and therefore are more careful about their health and less frequently ascend at very high altitude areas. In this study, tourists in age 20 to 60 were more susceptible than those older than 60 years. It seems, thus, that the finding from this study agrees with previous studies.

Poor health condition before entering a high altitude area has been reported as a risk factor (11;22). We found that the prevalence of AMS among people with a “poor or not very good” health condition before entering Tibet was significantly higher than those tourists with better health status. However, other diseases such asthma, diabetes, lung diseases overweigh or obesity did not affect the AMS prevalence, which is in accordance with previous studies (10;22).

The prevalence of AMS was higher in the subgroup of tourist who lacked experience of high altitude as compared with that previous experience in last three months. It may be explained by the lack of awareness; however, analysis shown that the awareness among the participants reached to 88% among both with or without previous experience in high altitudes. Therefore, it could be that those with altitude experience in the last three months kept paths of the physiological adaption the established during their last visit.

Based on the total sample, the prevalence of AMS among male was significantly higher than among females, but the relationship was not found in the subset two hotels' sample. Other studies have shown that the prevalence in men and women trekkers at Everest Base Camp is quiet equal, 51% and 53% respectively (10). However, women have a slightly greater risk for AMS when pregnant or taking oral contraception (10). Another study, in contrast, shows AMS to be significantly more frequent in males than in females (27.9%vs.23.6%) at intermediate altitude (11) and (69% vs.57%) at 5400 m above sea level in Nepal (23). In general, most articles indicated that there are most likely no substantial gender differences in susceptibility to AMS.

It is recommended to reduce or quit smoking at high altitude areas, because of lower oxygen saturation. However, three studies reported no different in AMS prevalence between smoker and non-smoker (10;11;23). In contrast, the present study reports a higher prevalence of AMS in smokers than among non-smokers. The awareness among two groups was almost same, more than 80%.

Taking medication aimed at preparing for meeting high altitude should reduce the prevalence of AMS; however, we found that the prevalence among those people was significantly higher. Those people had a higher awareness on AMS, but no difference on other characteristics. It could be that they have experienced AMS before, i.e. have a greater individual susceptibility to AMS. Further analysis must be conduct to test this hypothesis. It is also a discussion about lack of effectiveness of drugs they used.

4. Conclusions

The estimated prevalence of AMS among tourists in Lhasa is high and lies between 44%–50.8% using the LLSS AMS diagnostic standards (headache plus one other symptoms and LLSS≥ 3). It is more likely that we have underestimated than overestimated, because it is likely that a high proportion of tourists with AMS symptoms than without were among the responders. They may simply not manage to fill in the questionnaire due to headache and other AMS symptoms.

The prevalence of AMS was significantly higher in people who rapidly ascend to Tibet, middle aged, without experienced at high altitude and experienced previous AMS symptoms.

5. Future research and recommendations

Data from the present study should be analysed, especially multiple regression analysis, and additional in-depth interview should be conduct to illustrate the acute mountain sickness risk factors.

Due to change in the policy, foreign tourists are not allowed to enter Tibet alone, but only as a group under a guided of travel agency. The tour guide or travel agency could access foreign tourists better than hotels receptionist. Thus further studies on AMS among foreign tourists in Lhasa could be better performed if one could conduct a study based on randomly selected travel agencies.

As winter Tibet trips have been introduced, one should conduct research in the winter season, as the climate may increase the risk of AMS (6;81), and the risk factor pattern may differ from the summer season.

More tourists can be recruited if one could develop Spanish and French questionnaires.

Having a good self-reported health condition before entering high altitude is recommended, and middle age people and people who have experienced AMS symptoms should pay more attention on the AMS.

Information about the high prevalence of AMS, and the subgroups at high risk should be conveyed to doctors in those countries sending tourists to high altitude areas and tourist companies, and health and tourism authorities in Lhasa, Tibet.

We aimed at preparing an information brochures and web-page to spread the knowledge to authorities and tourists. However, further multivariate analysis must first be done.

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The cover picture accepted from the homepage of Network for University Co-operation Tibet – Norway: http://www3.hf.uio.no/tibetnorway/.

APPENDIX 1-5

Appendix 1

Lake Louise Score (LLS) for the diagnosis of Acute Mountain Sickness (AMS)

Appendix 2

Questionnaire - English version with consent form

Appendix 3

Questionnaire – Chinese version with consent form

Appendix 4

Introduction to the hotel in English

Appendix 5

Introduction to the hotel in Chinese