HIGH ALTITUDE WOES: WHAT THE CHINESE ARE HIDING

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The People's Liberation Army (PLA) of China is tasked with manning the borders of Chinese occupied Tibet with India. These borders are almost uniformly at ultra-high altitude, over 5 km high in places. Human life at such altitudes is difficult, and frequently susceptible to serious and life-threatening complications which call for urgent evacuation of sick soldiers to altitudes less than 3,000 m. The Chinese face a heavy burden of mountain sickness among their personnel that cannot be remedied by urgent evacuation to lower altitudes because of the unique geography of Tibet. Because Tibet itself is at an average altitude of over 4,000 m, there is no low altitude area suitable for evacuation for hundreds, or even thousands of kilometres from some parts of Tibet. A review of Chinese medical papers on the subject reveals the extent of the problem which the Chinese media and PLA mouthpieces fail to report. This is likely to have a detrimental effect on the morale and fighting capacity of the PLA.

TIBET: GEOGRAPHY AND DEMOGRAPHY

Constituting a land area of 1.2 million sq. km, occupied Tibet constitutes 12.5 per cent of the area of China. Less well known is the fact that Tibet

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has a population of just 3.6 million people, a miniscule 0.25 per cent of the total population of China, with a population density of just three people per sq. km, compared to 166 people per sq. km in eastern China. The entire population of Tibet can be accommodated in a city the size of Pune, in India. Thirty-five Chinese cities have a population greater than the whole of Tibet. This is a consequence of the high altitude and harsh climate in Tibet, in which only native Tibetan people, who have survived there for thousands of years, can live active lives without fear of mountain sickness.

Tibet presents two debilitating hurdles to human survival. The first is its extraordinarily high altitude, which averages 4,400 m,[1] as a result of which the air contains too little oxygen for normal, unacclimatised people to live and work. Secondly, the climate is harsh, dry and cold. Such weather does not allow the abundant growth of crops. For this reason, Tibet can produce food to support only about three million people. When the population exceeds this figure, food has to be brought in from eastern China.

Literature about China, both military and political, exposes a blind spot on the question of the problems ethnic Han Chinese soldiers and workers face in occupied Tibet. Information is dominated by news of Chinese infrastructure building and the powerful Chinese military presence in Tibet. This is exactly the information that China wants to be seen by outsiders. However, when one starts digging into geographical facts and population statistics, it emerges that the occupation of Tibet throws up issues that the Chinese do not openly admit.

The disabilities and difficulties caused by living at very high altitudes are well known the world over. India has been at the forefront of scientific study of the problem of living at ultra-high altitudes because of the need to station

1. https://www.chinahighlights.com/tibet/altitude.htm, Accessed on July 10, 2022.

soldiers in Siachen, Ladakh and other Himalayan heights all year round.[2] Similar problems are faced by mountaineers from all nationalities, and for that reason, scientific papers about the causes, prevention and treatment of high altitude sickness can be found from all over the world.[3] But when one compares non-Chinese papers with Chinese scientific papers on the subject, it is possible to identify differences in perspective that reveal a set of unique issues that the Chinese face in Tibet. These differ from the experience of the rest of the world, including India. In order to recognise these differences, we must recount some basic facts about what is high altitude and high altitude sickness, better known as mountain sickness.

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ACUTE MOUNTAIN SICKNESS (AMS)

Mountain sickness comprises a set of symptoms that arise when people move from living in low altitude land, typically below 1,500 m to areas that are 3,000 m and higher.[4] For some people, the symptoms can start as low as 2,500 m. Most people have shortness of breath, reduction of exercise tolerance, fast heartbeat, headache, lack of sleep and other minor symptoms. These occur because of lack of oxygen at higher altitudes. To be technically accurate, the lack of oxygen is because the air pressure gets lower the higher one goes. The air pressure at lower altitudes is enough to allow the lungs to take in as much oxygen as they need at rest and during exercise. As one climbs higher in the mountains, the air pressure reduces and the lungs are less capable of taking in enough oxygen for the body.

2. Sikri, et al., "Is it Time to Revise the Acclimatization Schedule at High Altitude? Evidence From a Field Trial in Western Himalayas", *Med J Armed Forces India*, July 2019, 75(3), pp. 251-258.
3. AM Luks, ER Swenson, and P. Bärtsch, "Acute High-Altitude Sickness", *Eur Respir Rev* 2017, 26: 160096, at https://doi.org/10.1183/16000617.0096-2016. Accessed on July 10, 2022.
4. Maj Gen SR Mehta, VSM, et al., "Acute Mountain Sickness, High Altitude Cerebral Oedema, High Altitude Pulmonary Oedema: The Current Concepts", *Medical Journal Armed Forces India*, April 2008, 64(2): 149-153.

Breathing becomes faster as the body demands air, and any attempt to do any exercise increases the oxygen demand and makes the condition worse. Climbing rapidly to altitudes above 3,000 m can sometimes lead to severe, life endangering conditions such as HAPE (High Altitude Pulmonary Edema) in which fluid builds up in the lungs, or HACE (High Altitude Cerebral Edema) in which dangerous brain swelling occurs. In HAPE, the sufferer can drown in the fluid in his own lungs, and swelling of the brain in HACE can cause a fatal reduction in the supply of blood to the brain.

Up to 80 per cent of people may develop symptoms when they reach an altitude of 3,000 m from lower altitudes. People must take certain precautions in order to feel better and avoid life-threatening complications when they move up to higher altitudes. The figure, 3,000 m, is an important threshold because mountain sickness is rare at altitudes lower than 3,000 m and the symptoms disappear when a person with mountain sickness descends below 3,000 m. This fact is the basis for maintaining pressurisation in cabins of passenger aircraft at a figure corresponding to about 3,000 m. It takes about 48 to 72 hours for the body to acclimatise to this altitude and medical advice followed the world over is rest for that period, avoidance of exercise and maintaining adequate hydration by drinking plenty of fluid. Worsening of symptoms can easily be treated by descending to a lower altitude, though medicines such as acetazolamide (Diamox), along with supplemental oxygen inhalation, can help tide over minor symptoms. Ascending higher than 3,000 m calls for going up no more than 500 m at a time and resting for another two or three days at that altitude. An alternative is to ascend in the day and descend to the lower base for the night. This is often called "Climb High Sleep Low." The importance of these measures has been proven by the Indian Army and by mountaineers from many nations.

But the Chinese experience appears to be different, because of the problems China faces in stationing ethnic Han soldiers and workers from eastern China in Tibet. We can look at these in turn, starting with the unique geography of Tibet.

THE CHINESE EXPERIENCE: GEOGRAPHY OF TIBET

Tibet is a unique geographical region whose average altitude is nearly 4,400 m. This altitude is far above the level at which most people in the world can survive to lead an active, healthy life. Only native Tibetans have genetic changes, developed over centuries, that allow them to live in Tibet. The only other human group to have genetic changes that allow life at high altitudes, live halfway across the world in the Andes mountains of Chile. It is important to note that people who live at lower altitudes, or lowlanders like most Han Chinese, cannot live in high altitude areas without a period of acclimatisation. Even after such acclimatisation, lowlanders suffer a greater number of health problems if they live for long periods at high altitudes. In addition, lowlanders who return to low altitudes soon lose their acclimatisation and need to repeat the process of acclimatisation if they have to return to high altitudes.

For these reasons, the Chinese have not managed to fill Tibet with Han Chinese. Despite occupation of Tibet for over 70 years, 91 per cent of the people in Tibet are native Tibetans.[5] The Han Chinese account for about 6 per cent and most of them are non-permanent residents, moving in and out of the Lhasa area. As a place to live, Tibet is quite hostile to life. Crops do not grow easily at those altitudes in that climate and agriculture can barely support the 3.65 million people who live there. The Chinese, who had hoped to industrialise Tibet to improve its economy, have now changed track and are looking more at using tourism to increase Tibet's economic output. Still, Chinese investments in Tibet, mostly for infrastructure, far outstrip the economic value that Tibet can contribute.[6, 7]

5. https://www.tibetanreview.net/prc-census-puts-tibet-autonomous-region-population-at-3-65-million/. Accessed on June 10, 2022.
6. Andrew M. Fischer, "Tibet's Economic Growth an Accounting Illusion?", Institute of Social Studies (The Hague), at https://www.eastasiaforum.org/2015/07/09/tibets-economic-growth-an-accounting-illusion/. Accessed on July 10, 2022.
7. Andrew Martin Fisher, China Perspectives, "The Political Economy of Boomerang Aid in China's Tibet", at https://www.boell.de/sites/default/files/assets/boell.de/images/download_de/Fischer_CP_2009_Boom_Aid.pdf. Accessed on August 10, 2022.

ENTERING TIBET: ACCLIMATISATION

A fact that is almost unknown about Tibet is that there is almost no place in Tibet where the altitude is less than 3,000 m. Table 1 below shows a list of cities in Tibet with their respective altitude. It must be noted that Chamdo, Nyingchi and Pome are in the east, close to the Arunachal Pradesh border. They are over 1,500 km from Aksai Chin where the Chinese maintain sizeable military forces. Zhangmu port is at the Nepal border.

Table 1

City	Altitude
AMDO	4,800 m
NAGQU	4,500 m
NGARI	4,500 m
TINGRI	4,300 m
GYANTSE	4,000 m
SHIGATSE	3,800 m
BURANG	3,700 m
LHASA	3,650 m
TSETANG	3,580 m
CHAMDO	3,200 m
NYINGCHI	3,100 m
ZHANGMU PORT (NEPAL BORDER)	2,800 m
POME	2,750 m

Although lower altitude areas are present close to Tibet's border with Arunachal Pradesh, direct connectivity with these areas from the lowland areas of eastern China is poor because of the geography. This presents the Chinese with a problem that they do not directly admit in public, but about which one can find evidence in academic papers about mountain sickness from China. Normally, acclimatisation for people ascending to high altitudes requires that they spend two or three days at 3,000 m and then ascend in steps of 500 m. But in Tibet, the Chinese have to come directly from a low altitude to Lhasa, which is itself at 3,650 m. Because road travel from eastern China is difficult and not available throughout the year, air travel and travel by train are the preferred routes. By both routes, travellers reach the high altitude

Lhasa from lowland China in less than 24 hours. For this reason, symptoms of mountain sickness are common in travellers to Lhasa from China. Soldiers of the Chinese Army too face the same problem of finding themselves at over 3,500 m in one day after leaving the lowlands. Normally, such a change in height should take four or five days, but for the Chinese this is physically not possible because the geography between eastern China and Tibet does not allow it. There is no interim area for acclimatisation at 3,000 m in Tibet. From lowland China, the first destination is high altitude Lhasa.

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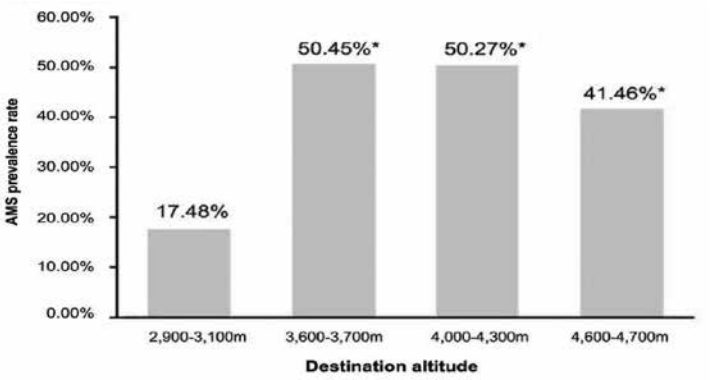
The following quote from a Chinese medical paper[8] about the problem of mountain sickness when PLA troops are rapidly inducted into Tibet for a military emergency. This particular study was of 4,367 soldiers, between the ages of 19 and 22. Over 50 per cent of them developed Acute Mountain Sickness (AMS) at and above the Lhasa altitude of 3,600 m as shown in the graph reproduced below from the publication (Fig 1).

Fig 1



8. Xiaoxiao Li, et al., "Factors Associated With Acute Mountain Sickness in Young Chinese Men on Entering Highland Areas", *Asia-Pacific Journal of Public Health* 27(2), December 2011.

The article notes:

> In this study, we found that the risk of AMS was higher for emergency deployment by land than for normal deployment by air, although air transportation had a quicker ascent rate. There are several reasons for this. First, emergency deployment by land implies a hard and strength-consuming mission. Second, on the Qinghai-Tibet Plateau, the road conditions are mostly terrible, and the soldiers are always transported by trucks. Third, when soldiers travel to high altitudes by land, they are usually exposed to bad weather, especially cold, wind, and snow, and food support during the trip is sometimes insufficient. In a word, emergency deployment by land is physically stressful, which accelerates the development of AMS.

Interestingly, the paper states: "In China, soldiers sent to the highlands were mainly first-year and second- year privates, and citizens younger than 16 years or older than 23 years were refused entry into the army as a private".

Another Chinese study[9] says that the incidence of AMS is as high as 16 per cent to 31 per cent on the Qinghai to Lhasa train even though oxygen concentrators are available on the train. Clearly, the PLA faces a high burden of mountain sickness among its soldiers, whether they arrive as routine inductions by train or as emergency deployments. The fact that the Chinese tend to post privates younger than 23 years in Tibet is also to be noted. Young age does not protect against AMS, but the fact may represent reluctance among senior personnel to undergo a hardship posting in Tibet.

The Wilderness Medical Society, whose guidelines for acclimatisation are widely followed around the world, makes the following recommendation:[10]

9. Wu Tianyi, et al., *A Unique Challenge in High-Altitude Medicine:The Qinghai-Tibet Railroad*, *Advances in High-Altitude Medicine and Hypoxic Physiology in China*, at https://www.science.org/do/10.1126/resource.2375830/full/bibms_booklet_2021_01_20.pdf. Accessed on July 10, 2022.
10. Wilderness Medical Society, "Clinical Practice Guidelines for the Prevention and Treatment of Acute Altitude Illness", Update, Andrew M. Luks, et al., June 24, 2019, at https://doi.org/10.1016/j.wem.2019.04.006. Accessed on August 11, 2022.

> With travel above 3000 m, individuals should not increase their sleeping elevation by more than 500 m/day and should include a rest day (ie, no ascent to higher sleeping elevation) every 3 to 4 days. The increase in sleeping elevation should be less than 500 m for any given day of a trip. In many areas, terrain and other logistical factors prevent strict adherence to this approach and mandate larger gains in sleeping elevation over a single day. In such cases, acclimatization days should be strongly considered before and/or after these large gains in elevation and elsewhere in the itinerary to ensure—at the very least and as an approximation of properly controlled ascent—that the overall ascent rate averaged over the entire trip (i.e., total elevation gain divided by the number of days of ascent during the trip) is below the 500 m per day threshold.

The Indian Army uses a standard acclimatisation schedule:[11] "The current acclimatization schedule being practised in our scenario of six days for altitudes between 2,700 to 3,600 m, four days for altitudes between 3,600 to 4,500 m and a further four days for altitudes above 4,500 m is time-tested and recommended".

This Indian Army schedule is conservative and errs on the side of safety. Some Indian studies suggest that faster acclimatisation is possible.[12]

In contrast to this, the Chinese acclimatisation schedule illustrates the lack of intermediate altitudes for staged ascent to high altitudes:[13]

> For all workers of lowland origin, to allow for acclimatization, graded ascent by train and bus over a period of 8 days was used. The workers travelled by train for 2 days to Xining (2,261 m), where they stayed for 2 days. They then travelled by train to Golmud (2,808 m), where they spent

11. Mehta, et al., n. 4.
12. Gaurav Sikri, et al., "Is it Time to Revise the Acclimatization Schedule at High Altitude? Evidence From a Field Trial in Western Himalayas", *Med J Armed Forces India*, July 2019, 75(3): 251–258, at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6676319/. Accessed on July 10, 2022.
13. Tian-Yi-Wu, et al., "Who Should Not Go High: Chronic Disease and Work at Altitude During Construction of the Qinghai-Tibet Railroad", *High Altitude Medicine & Biology*, vol. 8, no. 2, 2007.

a further 3-day acclimatization period, after which they were shuttled by bus to the construction sites at high altitude.

This Chinese method of acclimatisation would be unacceptable by any international standard. Possibly as a result of this, we find the following information about Chinese soldiers in Tibet:[14] in a study of 3,628 PLA recruits coming to Lhasa from low altitudes, 57 per cent had mountain sickness that affected daily activities and 12 per cent had symptoms severe enough to require hospitalisation for about three days. This is a revealing statistic. It means that if PLA troops numbering 10,000 personnel move into Lhasa from eastern China, 5,700 will have enough symptoms to interfere with daily activities and 1,200 will require hospital admission. However, after a few days, most will recover and start getting acclimatised. The initial burden is heavy.

But the Chinese altitude problem does not end there. Soldiers who acclimatise for Lhasa will still need to move up to 4,500 m or higher at the borders. Normally, this too would require a step-wise ascent of 500 m with two to three days rest at each 500 m increase. But Tibet has no such area that allows such step-wise ascent. Moving west from Lhasa, the nearest population centre is Shigatse, 220 km away, at an elevation of 3,800 m. West of Shigatse, heading parallel to the border with Nepal and India up to Aksai Chin, the terrain continues to rise above 4,200 m and stays above that altitude for the next 1,500 km frequently going higher than 5,000 m. For perspective, 1,500 km is the distance between Srinagar and Nagpur. Such an ascent, by road or by air, will once again result in mountain sickness for many, and more serious complications for a few. An indicator of how the Chinese attempt to manage this can be seen from reports that speak of oxygen enriched barracks:[15] "Every border company stationed at altitudes higher than 3,000 meters is equipped with oxygen machines. Soldiers there

14. Yusheng Ren, et al., "Incidence of High Altitude Illnesses among Unacclimatized Persons Who Acutely Ascended to Tibet", *High Altitude Medicine & Biology*, vol. 11, no. 1, 2010, a Mary Ann Liebert, Inc. DOI: 10.1089=ham.2009.1049. Accessed on July 10, 2022.
15. "China Prevents Altitude Sickness in Border Armies", at http://www.china.org.cn/china/military/2008-12/24/content_16998773.htm. Accessed on July 10, 2022.

are required to breathe in oxygen for an hour each day". The benefit of one hour of oxygen per day is questionable, as discussed below.

All internationally accepted protocols for treating the life-threatening condition of HAPE say that immediate evacuation to lower altitudes is the primary action needed to save life. Medicines and oxygen are adjuvants that must be given while awaiting urgent evacuation by the fastest possible mode, such as by helicopter. Anyone with serious illness will have to be evacuated to a level less than 3,000 m. For the Chinese in Aksai Chin, there is no such low altitude area for hundreds of kilometres, the nearest being in Xinjiang. The Chinese do not directly admit that they have no way of quick evacuation to lower altitudes for their soldiers or road workers in Tibet. However, one can get indirect information from medical papers published by Chinese authors.

For the treatment of serious complications such as HAPE, Chinese academic papers[16] advise a number of unconventional actions to be taken at the spot and mention evacuation only as the last act, giving the explanation that it may not be possible to evacuate people from remote areas. In the section on treatment of HAPE, ten steps are mentioned, and the first nine are oxygen and medicines, while evacuation, which should be considered very early, is mentioned at the very end using the words: "When possible, patients should be quickly transferred to lower altitudes (below 3,000 meters) for further treatment. […] However, descent treatment is only applicable in less remote areas within a relatively short amount of time. In remote mountain areas, where transportation conditions are extremely poor and continuous oxygen supplies cannot be guaranteed in transit, it is for the best to administer on-site treatment".

These are surprising comments. Contrary to the advice in all other international journals that recommend immediate evacuation to a lower altitude, the authors of this paper accept that such evacuation may not be possible and that on-site treatment is the only possibility to save life. Under

16. Zhou Qiquan and Luo Yongjun, "High Altitude Pulmonary Edema", at www.intechopen.com; https://pdfs.semanticscholar.org/8e3f/8242ad671143c148e6d2a409553b3bdd97f2.pdf. Accessed on July 10, 2022.

Chinese reports say that HAPE occurs in 1.9 per cent of soldiers entering Tibet. Extrapolating this statistic, it can be calculated that this life-threatening condition, requiring hospitalisation, will occur in 190 soldiers out of every 10,000 soldiers inducted into Lhasa.

such restrictions, the number of deaths is bound to be high.

The absence of low altitude areas in Tibet which can receive seriously ill soldiers by air evacuation probably explains the emphasis on road transport. While these conclusions can be deduced indirectly from a study of Chinese literature on the subject of mountain sickness, it is likely that the PLA does not want to admit the extent to which high altitude sickness affects its soldiers. But information about the burden of sickness they have is available in other medical papers.

Chinese reports say that HAPE occurs in 1.9 per cent of soldiers entering Tibet. Extrapolating this statistic, it can be calculated that this life-threatening condition, requiring hospitalisation, will occur in 190 soldiers out of every 10,000 soldiers inducted into Lhasa. This is a large medical burden, and since there is no staging either into Lhasa, or towards the higher reaches close to the Indian borders, the same disease burden can be expected closer to the border. The Chinese had reported a very high chance of death from HAPE in the past, reduced in recent times to 0.33 per cent of those affected by HAPE. That being said, statistics about the death rate of Han Chinese patients with HAPE in Tibet are hard to come by, and the Chinese seem to be experimenting with unconventional treatment regimens that continue to have a high possibility of death from HAPE. One report speaks of something called Bundle therapy that results in a 3 per cent chance of death, versus 10 per cent for the treatment they were using earlier. This needs to be viewed in context. If 10,000 soldiers are taken to Tibet then, as per Chinese statistics, 190 will develop life threatening HAPE, and will have to be transported to Golmud which is 1,500 to 2,000 km away. There, with the best "Bundle therapy" about six of those 190 men will die, while the others will recover after several days' treatment in an intensive

care unit. The logistical headache that the PLA is faced with under these circumstances is formidable. There is only one academic paper pointing to this solution, and it appears that the Chinese do not attempt this type of evacuation as a routine.

For a very ill soldier in northern Aksai Chin, the nearest low altitude hospital is in Xinjiang. This would mean evacuation by helicopter from areas that are already situated above 4,000 m in altitude, followed by a 300 to 400 km journey over the 6 km high Kunlun mountains. No Chinese report mentions this as a possibility. Additionally, no Chinese helicopter is capable of making such a journey currently. The optimum possibility for a sick PLA soldier in the Galwan, Gogra, Pangong or Spangur lake area would be evacuation by road or helicopter to Rutog which is itself at 4,200 m, but has better medical facilities. From here, the best chance for evacuation to the nearest low altitude area in Xinjiang would be further transport to Ngari Gunsa airfield, over 150 km away but also at an altitude of 4,200 m. From here, an aircraft would be needed to fly the patient to Xinjiang, or to more distant destinations like Golmud, to reach altitudes less than 3,000 m. A patient who is seriously ill with HAPE needs constant monitoring and therapy with drugs and oxygen and will have to be accompanied by medical personnel. The use of a small portable high-pressure chamber for the patient is complicated by the fact that it interferes with minute-by-minute monitoring of the patient and is unsuitable for a prolonged journey by road. Articles in Chinese medical journals are on record pointing out that road journeys are arduous and excessive movement of the patient on sinuous mountain roads is detrimental to the patient's health and monitoring. With such difficulties in evacuation to lower altitudes, it is no

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surprise that the Chinese violate all medical recommendations to try and treat HAPE while remaining at high altitudes without the crucial step of evacuation to lower altitudes. It is unlikely that the results are gratifying.

CHRONIC MOUNTAIN SICKNESS

Even among those lowland Han soldiers from eastern China who successfully acclimatise and reach Ladakh altitudes, there is a further disease burden known as Chronic Mountain Sickness or CMS. This affects acclimatised people who spend several months or years at high altitudes. The symptoms include headache, lack of sleep, palpitation, shortness of breath and other problems that are easy to ignore but have a significant impact on the workforce, especially among those whose work involves exertion as would be expected of soldiers and construction workers. CMS causes loss of work days amounting to two months per year at Lhasa altitudes, and three and a half months per year at Aksai Chin altitudes. The condition can be reversed only by returning the patient to a low altitude area, which may be thousands of kilometres away for a Chinese soldier posted in Tibet. Overall, the burden of disability from CMS for Han Chinese in Tibet is 15 days per year for every immigrant. This statistic conceals the actual burden of disability in the extra-high altitudes of Aksai Chin. One medical paper[17] reports that these disabilities were thought to be something that could "be overcome by will-power and courage derived from military discipline and patriotism." But the same paper goes on to report that the disability burden is very high, resulting in incapacitation of roughly 23 per cent of all men in altitudes equivalent to that of the Depsang plain which is over 5,000 m high. This problem is carefully hidden by the PLA. A supplemental burden they face is that CMS is more likely among smokers, and 25 per cent of Han Chinese are reported to be smokers, with the prevalence as high as 50 per cent among younger individuals whose age profile matches that of PLA recruits.

17. Tao Pei, et al., "Burden of Disease Resulting from Chronic Mountain Sickness Among Young Chinese Male Immigrants in Tibet", *BMC Public Health*, 2012; 12: 401, at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3444415/. Accessed on July 10, 2022.

The high incidence of CMS is one of the reasons why the Chinese find it difficult to keep ethnic Han Chinese living at high altitudes in Tibet for prolonged periods of time. The need to rotate soldiers from Tibet to and from eastern China, 2,500 km away, makes it difficult to maintain a local cadre of senior long-term residents with experience of local conditions. Remoteness and distance play a role in the low morale and unwillingness of Han Chinese personnel who need to be placed in Tibet.

OXYGEN ENRICHED BARRACKS

Reports of oxygen enriched barracks built for the PLA in high altitude areas are indicative of attempts to mitigate the problem. Symptoms of mountain sickness can be reduced by increasing the amount of oxygen in the air that is breathed at high altitudes. This is why passengers on the Xining to Lhasa train from eastern China, who include soldiers, are provided with extra oxygen in the cabin air, supplemented, when necessary, by piped oxygen for individuals in case symptoms occur despite cabin air enrichment with oxygen. However, once the travellers reach Lhasa, they can still get acute mountain sickness. Although Lhasa, the capital city of Tibet, is situated at an altitude of 3,650 m, native Tibetans rarely get mountain sickness because they are genetically tolerant to low oxygen air from birth. However, ethnic Han Chinese, who constitute the majority of soldiers of the PLA, are prone to mountain sickness.

Research shows[18] that sleeping in oxygen enriched barracks at night improves sleep quality and the positive effect lasts for some hours after they leave the barracks. However, there are disadvantages to the use of enriched oxygen in the barracks.[19] People who sleep in oxygen enriched barracks suffer from delayed acclimatisation and they would be intolerant to working during the day at higher altitudes. Soldiers who can get a good night's sleep

18. Guang-Hao Shen, et al., "Effects of Oxygen Enriched Tent by a New Oxygen Concentration Machine on Blood Oxygen Saturation and Heart Rate in Tibet", *J. Biomedical Science and Engineering*, 2011, April, 130-135, at http://www.SciRP.org/journal/jbise/. Accessed on July 10, 2022.
19. John B. West, "Potential Use of Oxygen Enrichment of Room Air in Mountain Resorts", *High Altitude Medicine & Biology*, vol. 3, no. 1, 2002.

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every night in well oxygenated barracks will not be ready for long patrols lasting several days that take them up to higher altitudes in the mountains. An additional disadvantage in oxygen enriched barracks is a fire hazard. Cooking with open flames would not be allowable in such an environment. Research also shows that full acclimatisation at heights of over 5,000 m may take up to two weeks and under these conditions, oxygen supplementation has been used for workers at high altitude telescopes in mountains. There is evidence that intermittent exposure to high altitudes can delay acclimatisation for up to two and a half years.[20]

Oxygen enrichment of barrack air can theoretically be done using oxygen cylinders, but the volumes needed are so huge that using cylinders would be a logistical headache. The method used to extract oxygen from the air is by oxygen concentrators. These machines pump compressed air through a mineral called zeolite which absorbs nitrogen from the air allowing oxygen to pass through so that nearly pure oxygen comes out of the zeolite. Two tanks of zeolite are used so that when one is saturated with nitrogen, the other is used to provide oxygen while the saturated zeolite is pumped with air to expel the excess nitrogen. The system requires electricity for the pump. Another system of oxygen enrichment is called a membrane oxygen generation system where air is passed through a membrane separator to separate the oxygen from the nitrogen.[21] Such systems are available in various capacities and the power requirement starts at 3 kilowatt (kW) for the lowest end machines to about 20 kW for the high-capacity ones.

20. Jorge G. Farias, et al., "Sustained Acclimatization in Chilean Mine Workers Subjected to Chronic Intermittent Hypoxia", *High Altitude Medicine & Biology*, vol. 7, no. 4, 2006.
21. "Nitrogen Separation Membrane Technology", at https://www.pcigases.com/oxygen-solutions/technology/membrane-technology/. Accessed on July 10, 2022.

The amount of power that would be required for oxygen concentration for Chinese soldiers in forward areas in Aksai China can be roughly estimated as follows. Exact estimates are not possible because there will always be air leaks in barracks and the actual usage will depend on real-time estimates of oxygen concentration. For soldiers in Tibet, every 1 per cent increase in oxygen concentration causes a simulated reduction in altitude by 300 m. That means that for soldiers at 4,500 m in Aksai Chin, room air concentration needs to be increased by 5 per cent, from 21 per cent to 26 per cent to simulate a more tolerable altitude of 3,000 m. A room with two people requires a power supply of about 1.4 kW, or 33 kilowatt hours (kWh) in a day. For a brigade of Chinese soldiers (5,000 men) accommodated in oxygen enriched barracks in Tibet, the daily power requirement would be 80,000 kWh. The average American household is said to use 30 kWh in a day. That means that one PLA brigade of 5,000 men would need the same amount of daily electric power as 2,500 American homes for the supply of electricity for oxygen enriched barracks. However, the actual power requirement is probably only a fraction of this because the Chinese are reported as recommending just one hour of breathing extra oxygen per day for every soldier. Power lines and even small dams are seen near the town of Rutog just outside Aksai Chin, with the electric power line extending up to Chushul and the Chinese occupied parts of Pangong lake. In areas where the Chinese are not known to have power lines, such as Galwan valley, either the Chinese cannot provide that amount of power, or it is being supplied by means of oil powered generators, or solar power. The presence of what appear to be residential structures close to the Line of Actual Control (LAC) in Ladakh seems to support the idea that the Chinese have built facilities for oxygen enrichment.

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The recommendation for Chinese soldiers to breathe oxygen for one hour a day is a half-hearted measure that will neither aid acclimatisation

nor break away the desire of soldiers to get back to the barracks for their daily oxygen. One Chinese report[22] says:

> …cessation of oxygen therapy might lead to withdrawal effects or addiction phenomena. Oxygen therapy in high-altitude areas can relieve symptoms, improve sleep quality, and reduce pulmonary artery pressure in patients with CMS, those at high risk for CMS, and healthy individuals living on the plateau; however, these benefits might not last after stopping inhalation.

CONCLUSIONS AND POSSIBLE MILITARY IMPLICATIONS

The PLA is known to be most ready for war in the June to September period every year. After September, fully trained recruits who have completed two years, leave the army, reducing its strength, while fresh recruits join in September. The PLA deputes the youngest raw recruits to man high altitude areas and most of the men are between the ages of 19 and 22 years. Recruitment into the PLA has been affected by the reputation of Tibet as a hardship posting. This would explain the photographs and reports that have appeared of young PLA recruits weeping when being posted there.

The correct treatment for serious complications of AMS is emergency evacuation to a place that is at 3,000 m or lower. Tibet, particularly western Tibet, where Aksai Chin is situated, lacks easy access to such a low altitude area.

It is evident from multiple medical papers that the Chinese face a unique problem in getting troops and workers to acclimatise when entering Tibet and serious logistical hurdles in evacuation of seriously sick people to altitudes of 3,000 m or less. At a time of massive mobilisation of troops from eastern China into Tibet, or in the June to September period when the PLA conducts

22. Bin Feng, et al., "Intermittent Oxygen Inhalation with Proper Frequency Improves Overall Health Conditions and Alleviates Symptoms in a Population at High Risk of Chronic Mountain Sickness, with Severe Symptoms", *Chinese Medical Journal*, vol. 129, issue 11, June 5, 2016.

its exercises near Ladakh, the Chinese will have a heavy burden of soldiers with mountain sickness.

The Chinese find it difficult to maintain a permanent cadre of Han Chinese in Tibet because of the problem of chronic mountain sickness which is common among Han Chinese and rare among ethnic Tibetans. The only cure is to repatriate the Han Chinese back to low altitude areas. As a result of this, the Chinese have failed to repopulate Tibet with Han Chinese the way Xinjiang has been repopulated. The high-altitude problem is absent in Xinjiang.

Emergency evacuation of personnel with serious mountain sickness related complications like HAPE and HACE to low altitude areas is difficult or not possible for the PLA because of the geography of Tibet. The Chinese are forced to resort to sub-optimal treatment locally without evacuation, which results in greater chance of death of personnel or long recovery time.

The PLA tries to compensate for these problems by providing facilities for oxygen enrichment in the soldiers' living quarters where the soldiers are required to breathe oxygen for one hour a day. This delays acclimatisation and can lead to oxygen addiction wherein the soldiers become dependent on their daily extra oxygen intake. The provision of oxygen enrichment adds to the logistical burden and demands power supply right up to remote border areas. This requirement needs fixed infrastructure as well as power supply and maintenance personnel. In case of a border conflict at Himalayan altitudes, the physical fitness and morale of the personnel who have been dependent on daily doses of oxygen will be suspect.