Asia Pacific
Academy of Science Pte. Ltd.

ORIGINAL RESEARCH ARTICLE

Research on a monitoring and evaluation platform for mountain sickness of grid construction workers based on disease information entropy

Donglai Tang[1], Ying Yang[2], Ping Li[3], Juntai Tian[1], Hongfei Ye[1], Jin Guo[1]*

[*1]*Aostar Information Technology Co., Ltd., Chengdu 610074, Sichuan, China. E-mail: tangdonglai@sgitg.sgcc.com.cn*
[2]*Department of Rehabilitation Medicine, People's Hospital of Suzhou High-tech Zone, Suzhou 215000, Jiangsu, China*
[3]*Customer Service Center, State Grid Sichuan Electric Power Company, Chengdu 610041, Sichuan, China*

ABSTRACT

The inaccuracy of acute altitude sickness screening has brought great challenges to power grid construction workers in high-altitude areas. Human vital signs monitoring technology is an effective technical means to prevent people from developing altitude sickness. This paper proposes a monitoring and evaluation platform for high altitude sickness in power grid operations based on information entropy of the causes of the illness. First, the vital characteristics data of workers are collected through sensors such as blood pressure and blood oxygen. Secondly, the collected data is transmitted back to the platform by using the Internet of Things technology. The information entropy establishes an analysis model of altitude sickness and generates personnel evaluation reports and treatment recommendations. Finally, the application results of the platform verified that the preventive effect of the platform is much higher than that of the pre-existing physical examination method.

Keywords: power grid field operation; monitoring and evaluation of altitude sickness; illness cause information entropy

1. Preface

The average altitude of the Qinghai-Tibet Plateau is above 4,000 m. Affected by factors such as high altitude, thin air, low atmospheric pressure, low partial pressure of oxygen, and strong ultraviolet rays in the region, acute altitude sickness has become a major threat to the construction personnel of the power grid in Tibet[1,2]. According to severity, acute mountain sickness is divided into two types: Mild (reactive or acute altitude sickness) and severe (high altitude cerebral edema, high altitude pulmonary edema)[3]. The onset time of acute

mountain sickness is short, occurring within hours to days. If it is not treated in time, it will be life-threatening[4].

Surveys and studies performed by High Altitude Sickness Prevention and Control Center of State Grid Corporation of China have shown that when the power grid construction workers, whose original permanent residences were from low altitude areas just entered the Qinghai-Tibet Plateau, were likely to induce acute altitude sickness, with the total incidence of acute altitude sickness of 18.97%, of which the incidence rate of mild and

severe altitude sickness was 18.19% and 0.78%, respectively. It can be seen that among those who have just entered the Qinghai-Tibet region to perform power grids operations, experience high and harmful incidence of acute altitude sickness, which further poses a serious threat to their health[5].

Many scholars have done a lot of research on the prevention and treatment of altitude sickness among power grid construction workers. Literature[6] proposed the establishment of altitude sickness analysis software, using ultrasound examination, electrocardiogram and other methods to conduct pre-physical examinations for personnel entering the construction sites in the Qinghai-Tibet area. In literature[7], it was proposed that the method of establishing bone marrow nucleated red blood cell examination and analysis software be used to carry out the pre-analysis of construction workers in the Qinghai-Tibet area.

However, the above-mentioned altitude sickness prevention and control software have no effective method for predicting and screening acute altitude sickness. The only way to prevent and treat altitude sickness is to perform physical examinations on power grid construction workers in advance or to send them to the hospital for treatment after the power grid construction workers developed altitude sickness. Doing so often misses the critical period for the prevention and treatment of altitude sickness and causes permanent damage to the body of power grid construction workers[8]. At the same time, power grid infrastructure construction is often performed in remote areas. When the power grid construction personnel fall ill, power grid companies will not only have to spend a lot of manpower and material resources for treatment but also, the life safety of the patients cannot be guaranteed[9]. Meanwhile, the progress of power grid construction will also be delayed to varying degrees. In recent years, the state has attached great importance to the economic construction of the Qinghai-Tibet region, and the scale of power grid construction has continued to expand. According to statistics, more than 60,000 power grid construction workers enter Tibet and Qinghai regions every year to participate in power grid construction projects. As a result, the number of power grid construction workers suffering from acute altitude sickness is huge. If it cannot be effectively prevented and disposed of, altitude sickness will cause significant economic losses to power grid companies.

The Internet of Things technology has the characteristics of comprehensive perception, efficient information processing, convenient and flexible application, and can realize intelligent supervision and management of power grid operations[10–12]. The Internet of Things technology, especially with the use of mobile internet technology, allows the realization of mobile communication between the grid construction personnel and the back-end systems[13,14]. The use of the technology can provide vital sign data transmission support for the prevention and treatment of altitude sickness for power grid construction workers in the Qinghai-Tibet region.

Given the above background, this paper proposes a monitoring and evaluation platform for high altitude sickness for power grid construction workers based on the data of human vital signs collected and transmitted by the Internet of Things and mobile internet technologies. The platform can collect real-time data of the life characteristics of power grid construction workers and timely analyze the warning risks and provide treatment plans of the said workers in the Qinghai-Tibet region through the information entropy modeling of the causes of altitude sickness to prevent the occurrence of altitude sickness among power grid construction workers in advance. The application results of the high altitude sickness monitoring and evaluation platform for power grid construction workers verify that the prevention effect attained from this platform is much higher than that of the pre-physical examination method, and it can effectively reduce the incidence of high altitude sickness among power grid construction workers.

2. Analysis on the characteristics of altitude sickness among power grid construction workers

Based on the survey of altitude sickness among power grid construction workers of the High Altitude Disease Prevention and Control Center of State Grid Corporation of China, Suzhou High-tech Zone People's Hospital analyzed 452 patients on the illness causes characteristics among power grid construction workers suffering from altitude sickness. From the results, it was summarized that there were 7 types of causes for altitude sickness with characteristic data that can be categorized into 4 categories and 16 subcategories.

Table 1. Analysis on the causes of altitude sickness among construction workers

Cause of illness	Metric	Number of patients	Proportion of patients/%
Original altitude	≤ 1,000 m	415	91.81
Time of construction workers to enter The high altitude area	≤ 5 days	291	64.38
Acclimation time at mid-altitude areas	≤ 2 days	391	86.50
Psychological factors	≤ Class III	215	47.57
Construction labor intensity	≥ Class II	442	97.79
Age	≥ 50 years old	87	19.25
Respiratory infection	≥ mild	142	31.42

From **Table 1**, it can be seen that the causes of altitude sickness among power grid construction workers from high to low include construction labor intensity, original altitude, acclimatization time in mid-altitude areas, time of construction workers entering the high altitude area, psychological factors, respiratory infection and age. Based on this, in the early stage of the grid construction workers entering the high altitude area, the cause of the construction workers becoming altitude sickness patients should be included in the information entropy analysis of the causes of illness and focus on observing the people whose original altitude, acclimatization time in mid-altitude areas and construction labor intensity that exceeded the threshold.

The characteristic data of power grid construction workers suffering from altitude sickness are listed in **Table 2**.

It can be seen from **Table 2** that after the power grid construction workers suffer from altitude sickness, the physical characteristics are mainly composed of 4 major categories and 16 subcategories including respiratory, cardiovascular, digestive and urinary system abnormalities. In this, it is necessary to combine the causes of altitude sickness and the characteristics of altitude sickness data as a joint source for information entropy modeling. When the power grid construction workers have abnormal physical characteristics, effective treatment and rescue are then able to be carried out to prevent such personnel from developing altitude sickness.

3. High altitude sickness monitoring and evaluation platform process

Figure 1 shows the overall process of the monitoring and evaluation platform for altitude sickness among power grid construction workers. The architecture mainly includes three links: data collection and transmission of construction personnel's vital signs, information entropy modeling of the causes of altitude sickness, and evaluation and treatment of the power grid construction personnel.

Table 2. Data sheet of altitude sickness characteristics of construction workers

| Category	Name of illness characteristic data	Eigenvalues
Respiratory system	BMI index/(kg·m^{-1})	≥28.3
	Lung function-FVL/L	≥3.47
	Lung function-FEV1/L	≥3.23
	Lung function-FEE25/(L·sec^{-1})	≥4.51
	Lung function-SaO$_2$ Decrease/%	≥83.9
	Number of breaths/(times h^{-1})	≥35
	Breathing pause time/s	≥10
Cardiovascular system	ECG ST-segment/%	≥40.1
	Diastolic blood pressure/mmHg	≤65
	Systolic blood pressure/mmHg	≥135
	Heart rate ≥ 100 times/min	≥30
	Red blood cells/(pcs L^{-1})	≥10
	Hemoglobin/pg	≥35
Digestive system	Abdominal muscletone/(number of spasms h^{-1})	≥2
	Urine red blood cells/(/ul)	≥50
Urinary system	Urine protein/(mg L^{-1})	≥150
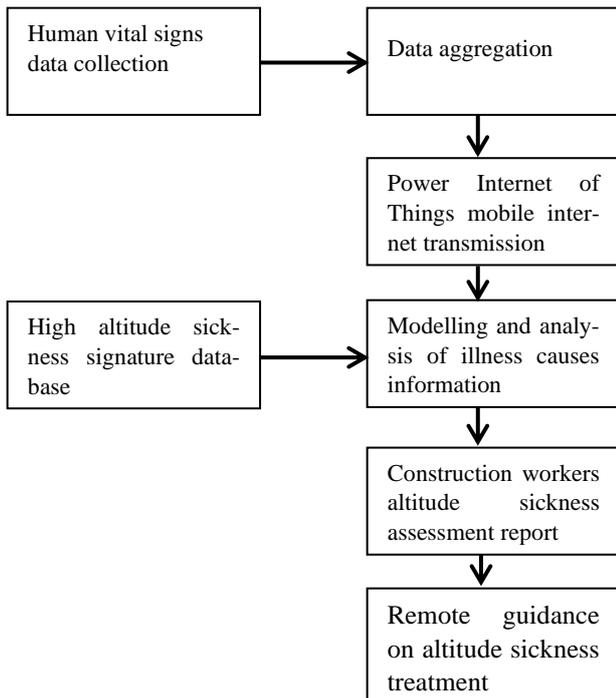
Figure 1. Overall process of altitude sickness monitoring and evaluation platform.

The human vital sign data collection module monitors the personnel's blood pressure, blood oxygen, electrocardiogram and other characteristic data in real-time through the vital sign sensors wearable by the grid construction workers. The data aggregation module uses the data-centric self-organizing algorithm based on the information negotiation sensor network protocol (Sensor Protocols for Information Via Negotiation, SPIN) to realize local aggregation of vital signs data of multiple construction workers. In the mobile interconnection transmission module of the power Internet of Things, the local data is transmitted back to the altitude sickness prevention and control platform of the power grid construction personnel of the power supply company through the 5G network. In the information entropy modeling and analysis of the causes of altitude sickness, experience data of the expert knowledge base can be combined with the collected characteristic data for modeling analysis to generate the risk assessment report of altitude sickness for power grid construction workers. Finally, the wearable video transmission model is used to provide remote treatment guidance for altitude sickness prevention and treatment.

4. Data collection and transmission model of construction workers' vital signs

The power grid infrastructure construction in the Qinghai-Tibet region is mostly in remote areas.

Hence, the collection and transmission of vital signs data of power grid construction personnel mainly consider the reliability and cost of the collection and transmission. In this, the collection model includes two parts: wearable life feature data collection, wireless networking and aggregation transmission of data collected by multiple people in the construction team.

4.1. Wearable vital signs data collection

The vital sign data of power grid construction personnel is collected by wearable vital sign sensors. The sensors are mainly divided into heartbeat, cardiogram, blood pressure, blood oxygen, body temperature, respiratory rate and altitude. Additionally, several life feature collection points are also configured according to the conditions of the construction workers. This multi-sensors data fusion is carried out through neural network, wavelet transform and Kalman filtering technology[15,16] to obtain accurate measurement signals.

In this paper, the multi-sensor data-adaptive weighted fusion estimation algorithm is used to collect vital sign data.

There are *n* sensors to measure a grid construction worker where the variance of the sensor is $\boxtimes_1, \boxtimes_2, \dots, \boxtimes_n$, From the first measurement, the number of measurements is σ, while the estimated true value of the sensor measurement is x_{fa}, and the measurement value of each sensor is $x_1, x_2, \dots, x_n$ and the weighting factor of each sensor is $y_1, y_2, \dots, y_n$. After multi-sensor fusion, the weighting factor of x_{fa} is:

$$x_{fa}{}^n = \sum_{\sigma=1}^{n} \binom{n}{k} y_\sigma x_\sigma \tag{1}$$

Assuming that the second group is measured h times, the average variance of the sensor is:

$$\partial^2 = E\left[\sum_{\sigma=1}^{n} y_\sigma^2 (x_{fa} x_\sigma)^2 + 2 \sum_{\sigma=1,h=1}^{n} y_\sigma y_h (x_{fa} - x_\sigma)(x_{fa} - x_h) \right] \tag{2}$$

It can be seen from equation (2) that the average variance of the sensor is a multivariate quadratic function about each weighting factor and so has a minimum value. According to the multivariate function theory, to find the extreme value theory, the weighting factor corresponding to the minimum total mean square error can be obtained:

$$y_\sigma^h = 1 / \left(\partial^2 \sum_{\sigma=1,h=1}^{n} \frac{1}{\partial^2} \right) \tag{3}$$

At this time, the minimum variance corresponding to the multi-sensor is:

$$\partial_{min}^2 = 1 / \sum_{\sigma=1}^{n} \frac{1}{\partial_\sigma^2} \tag{4}$$

The multi-sensor data-adaptive weighted fusion estimate x_{fb} can be calculated from equations above:

$$x_{fb} = \sum_{\sigma=1}^{n} y_\sigma x_\sigma(\partial) \tag{5}$$

It can be seen from equations that through the data fusion of wearable vital signs multi-sensors, the accurate vital signs data of heartbeat, cardiogram, blood pressure, blood oxygen, body temperature and other types of power grid construction workers can be obtained.

4.2. Multi-person wireless networking and aggregation transmission

In the Qinghai-Tibet Plateau power grid construction site, several people are participating in the power grid construction work. If each construction worker occupies a 5G transmission channel, it will cause a waste of resources and an increase in transmission costs[17-19]. Therefore, the data-centric self-organizing algorithm SPIN can be used to achieve local aggregation of life characteristics data of multiple construction personnel.

In the SPIN multi-person wireless network of

23

power grid construction personnel, the geographical location of the construction personnel is randomly arranged, and each vital sign monitoring sensor node will first send a command to request the allocation level to the adjacent base point sensor. If the adjacent base point sensor is the convergence point, then the vital sign monitoring sensor node will receive the level assigned by the convergence point, and the sensor node will send the vital sign information datagram to the convergence point. If the adjacent node sensor is another transit vital sign

monitoring sensor, the sensor node will send vital sign information data to the transit sensor. Through the SPIN routing algorithm networking, each sensor node hopes to become a transit node and guides its transmission path to the aggregation node. In order to reduce the loss of node transmission, the vital sign sensor nodes of each construction worker negotiate directly during transmission to achieve the best transmission efficiency. The schematic diagram of SPIN multi-person wireless network is shown in **Figure 2**.
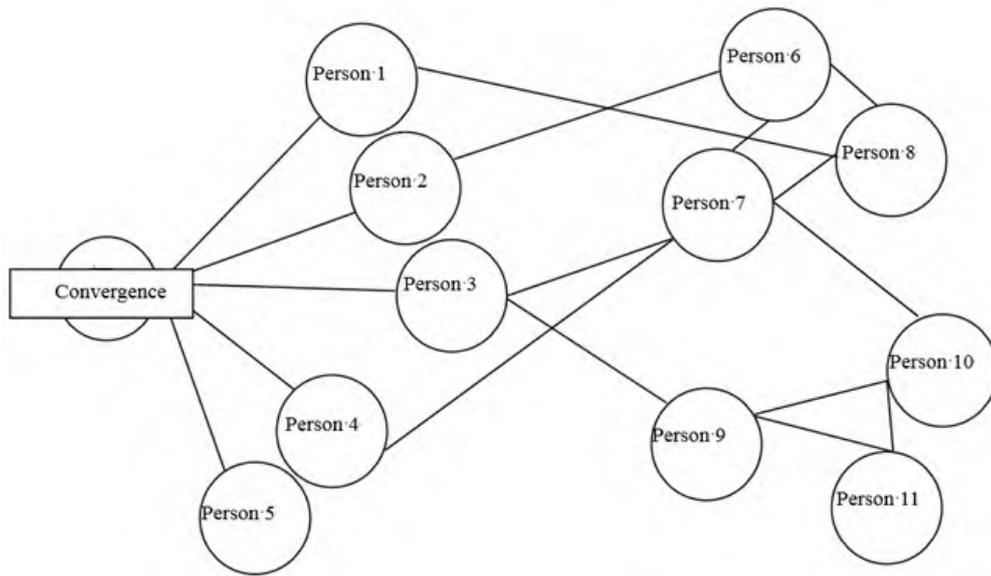

Figure 2. SPIN multi-person wireless networking.

When the vital sign data of each power grid construction worker reaches the convergence point, the 5G network is used to transmit the data to the monitoring and evaluation platform of high altitude sickness for power grid construction workers of the power supply company through the multi-level security architecture of the Internet of Things[20].

5. Causes of altitude sickness information entropy modeling

The information entropy of the causes of altitude sickness mainly involves the traceability analysis of the causes of altitude sickness to power grid construction workers, respiratory system, cardiovascular system, digestive system, and urinary system. Based on the analysis of the characteristics of

altitude sickness among power grid construction workers, a two-layer cause of altitude sickness information entropy modeling was carried out comprising of the independent information entropy of the causal factors and the combined information entropy of altitude sickness.

5.1. Modeling of independent information entropy of the cause factors

Traceability modeling of the causes of altitude sickness

The traceability of the causes of altitude sickness mainly includes seven aspects. The range of values for the traceability characteristics of the causes of high altitude disease is listed in **Table 3**.

Table 3. The value range of the traceability characteristics of the causes of high altitude sickness

Cause of illness	Lower limit	Upper limit
Altitude of the original location/m	0	4,000
Time of construction Workers to enter the high altitude area/day	0	60
Acclimation time at mid-altitude areas/day	0	60
Psychological factors/class	1	VI
Construction labor intensity/class	1	VII
Age/years old	18	65
Respiratory infection	No infection	Severe

Let z be the information entropy of tracing the causes of altitude sickness, the altitude of the original location is z_a, the labor intensity of construction is z_b, the acclimatization time in the mid-altitude area is z_c, the time for construction workers to enter the high altitude area is z_d, the psychological factors is z_e, and the respiratory infection is is z_f, age is z_g, and the cause entropy for tracing the origin of altitude sickness is:

$$H(z)$$
$$= H(z_a) + H(z_b) + H(z_c) + H(z_d) + H(z_e)$$
$$+ H(z_f) + H(z_g)$$
$$+ Hz(z_a|z_b|z_c|z_d|z_e|z_f|z_g) \qquad (6)$$

Respiratory system modeling

There are 7 main aspects of respiratory system modeling. According to the breathing data monitored by the vital sign sensors, the monitoring data such as pauses of more than 10 s are generated by detecting the rapid breathing of a worker and the continuous 3 or 4 rapid breathing to determine the risk of altitude sickness onset. The value range of respiratory system characteristic value is listed in **Table 4**.

Table 4. Value range of respiratory system characteristics

Name	Unit	Lower limit	Upper limit
BMI Index	kg/m	10	50
Lung function-FVL	L	0.5	10
Lung function-FEV1	L	0.5	10
Lung function-FEE25	L/sec	0.5	10
Lung function-SaO decrease	%	0	99
Number of breaths	number/h	5	100
Breathing pause time	s	0	100

Let the information entropy of the respiratory system be x, the BMI index to be x_a, the lung function-FVL to be x_b, the lung function-FEV1 to be x_c, and the lung function-FEE25 to beis x_d, the decrease in lung function-SaO2 is x_e, the number of breaths is x_f, the breathing pause time is x_g and the entropy of respiratory system pathogenesis is:

$$H(x) = H(x_a) + H(x_b) + H(x_c) + H(x_d)$$
$$+ H(x_e) + H(x_f) + H(x_g)$$
$$+ H(x_a|x_c|x_d|x_e|x_f|x_g) \qquad (7)$$

Cardiovascular system modeling

According to the heartbeat data, dynamic electrocardiogram data, and blood pressure data monitored by the vital sign sensors, detection on the whether there are increases in heart rate, blood pressure, red blood cells and hemoglobin as well as whether there are clinical symptoms present such as ectopic arrhythmia, can be used to determine the risk of altitude sickness. The value range of cardiovascular system eigenvalues is listed in **Table 5**.

Table 5. Value range of cardiovascular system characteristics

Name	Unit	Lower limit	Upper limit
ECG ST segment	%	0	90
Diastolic blood pressure	mmHg	20	140
Systolic blood pressure	mmHg	60	240
Heart rate ≥100 times	min	0	600
Red blood cells	number/L	0	9,999
Hemoglobin	pg	0	9,999

Having set the information entropy of the cardiovascular system as y, the ST segment of the

electrocardiogram as y_a, the diastolic blood pressure as y_b, the systolic blood pressure as y_c, the heart rate ≥ 100 times as y_d, the red blood cells as y_e and the hemoglobin as y_f, the source entropy of the cardiovascular system is:

$$H(y) = H(y_a) + H(y_b) + H(y_c) + H(y_d) + H(y_e) + H(y_f) + H(y_a|y_b|y_c|y_d|y_e|y_f) \quad (8)$$

Digestive system modeling

According to the intestinal peristalsis data monitored by the vital sign sensors, detection on whether the intestinal peristalsis is weak, the intensity of intestinal tension and other clinical symptoms can be used to determine the risk of altitude sickness. The eigenvalues of the digestive system characteristic range from 0 to 60 times/h.

Let the information entropy of the digestive system be p, the abdominal muscle tension (the number of spasms/h) be p_a, and the entropy of the source of the digestive system is:

$$H(p) = H(p_a) \quad (9)$$

Urinary system modeling

According to the blood data monitored by the vital sign sensors, detection on whether there are clinical symptoms such as hematuria and proteinuria can be used to determine the risk of altitude sickness. The range of urinary system characteristic values is listed in **Table 6**.

Table 6. Value range of urinary system characteristics

Name	Unit	Lower limit	Upper limit
Urine red blood cells	/μL	0	9,999
Urine protein	mg/L	0	9,999

Let the information entropy of the urinary system be q, the urine red blood cells to be q_a, the urine protein to be q_b, and the entropy of the urinary system to be:

$$H(q) = H(q_a) + H(q_b) + H(q_a|q_b) \quad (10)$$

5.2. Combined information entropy modeling of altitude sickness

In the information entropy modeling of the causes of altitude sickness, five cause variables of altitude sickness, respiratory system, cardiovascular system, digestive system, and urinary system are independent of each other. The amount of information obtained by observing the five variables should be the same as the amount of information of the five variables observed at the same time is the same. Let the amount of traceability information about the causes of altitude sickness be $s_i = s\{z=z_i\}$, the amount of information about the respiratory system is $a_i = a\{x=x_i\}$, and the amount of information about the cardiovascular system is $b_i = b\{y=y_i\}$, the amount of information in the digestive system is $c_i = c\{p=p_i\}$, and the amount of information in the urinary system is $d_i = d\{q=q_i\}$, then the information entropy of the causes of altitude sickness, the respiratory system, the cardiovascular system, the digestive system, and the urinary system are:

$$H(z) = \sum_{i \geq 1} s_i \log \frac{1}{s_i} \quad (11)$$

$$H(z) = \sum_{i \geq 1} a_i \log \frac{1}{a_i} \quad (12)$$

$$H(z) = \sum_{i \geq 1} b_i \log \frac{1}{b_i} \quad (13)$$

$$H(z) = \sum_{i \geq 1} c_i \log \frac{1}{c_i} \quad (14)$$

$$H(z) = \sum_{i \geq 1} d_i \log \frac{1}{d_i} \quad (15)$$

If in equations (11) to (15) the base of the logarithm is 2, then the information entropy of the causes of altitude sickness, respiratory system, cardiovascular system, digestive system, and urinary system are expressed as H2(z), H2(x), H2(y), H2(p), H2(q), respectively. At this time, the entropy unit based on 2 is bits. The curve of the entropy function is shown in **Figure 3**.
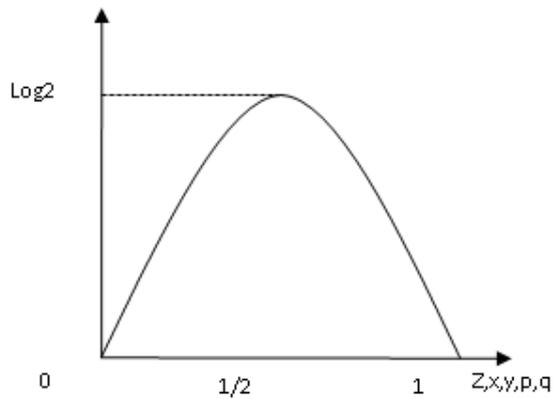
Figure 3. The curve of entropy function of illness source information.

Figure 4. Joint entropy graph of disease source information.

It can be seen from **Figure 3** that the $\log_2$ value of information entropy can be regarded as the amount of information provided by information entropy.

The joint entropy of altitude sickness is defined as the uncertainty of the simultaneous occurrence of five factors traceability of the causes, respiratory system, cardiovascular system, digestive system, and urinary system of altitude sickness. The joint entropy is:

$$H(z, x, y, p, q) = \sum(z, x, y, p, q)$$

$$s(z, x, y, p, q) \ \log \ s(z, x, y, p, q)$$

$$a(z, x, y, p, q) \ \log \ a(z, x, y, p, q) \tag{16}$$

$$b(z, x, y, p, q) = \log c(z, x, y, p, q) \tag{17}$$

$$c(z, x, y, p, q) = \log c(z, x, y, p, q) \tag{18}$$

$$d(z, x, y, p, q) = \log d(z, x, y, p, q) \tag{19}$$

$$H(z, x, y, p, q) = H(z) + H(x) + H(y) + H(p) \\ + H(q) + H(z|x|y|p|q) \tag{20}$$

Conditional entropy $H(z|x|y|p|q)$ can be regarded as the average amount of information lost due to interference and noise on the channel, and can also be regarded as channel noise or dispersion.

The joint entropy relationship and mutual information of the causes of altitude sickness are shown in **Figure 4**.
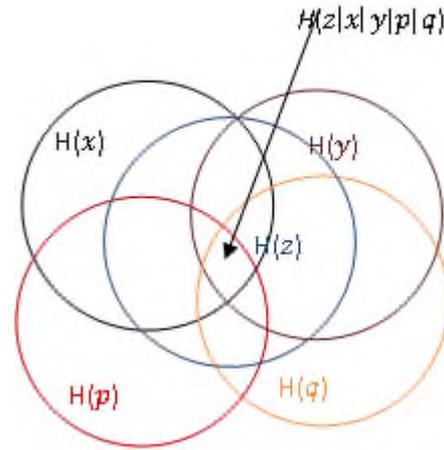
As shown in **Figure 4**, the intersection of $H(z)$, $H(x)$, $H(y)$, $H(p)$, and $H(q)$ is the joint entropy of altitude sickness $H(z|x|y|p|q)$, where the greater the value of the joint entropy of altitude sickness, the greater the difference between the five functions, which means the greater the probability of altitude sickness, to determine whether the power grid construction personnel would have the risk of altitude sickness.

6. Evaluation and treatment of power grid construction personnel

The monitoring and evaluation platform for power grid construction workers can accurately assess the risk of high altitude sickness among the workers after analyzing the probability of high altitude sickness among them based on the information entropy modeling of the causes of altitude sickness. At the same time, when combined with the expert diagnosis database of the altitude sickness patients, it is possible to accurately assess the risk of altitude sickness among power grid construction workers, and generate altitude sickness risk assessment reports and treatment recommendations according to the needs of the construction workers. The level of assessment generated is divided into three categories: mild, moderate, and critical risk while treatment recommendations include stopping work, resting on the spot, intake of glucose, oxygen therapy, and immediate sending to the hospital (see **Table 7**).

Table 7. Risk assessment level and treatment recommendations of altitude sickness

Serial number	Evaluation level	Treatment recommendation
1	Mild risk	Stop work, rest on site, glucose intake
2	Moderate risk	Oxygen therapy
3	Critical risk	Immediately send to hospital

The altitude sickness monitoring and evaluation platform for power grid construction workers send the evaluation report and treatment recommendations to the medical staff at the power grid construction site through the 5G network. The hospital staff on the site can then conduct on-site treatment to the power grid workers who were assessed to be at risk of altitude sickness or send them immediately to the nearest hospital according to the treatment recommendations.

7. Platform application analyses

On-site construction workers of 185 people working on a 330kV line in the Qinghai-Tibet region was selected to conduct analysis on the pre-

vention and treatment of altitude sickness. Before entering the Qinghai-Tibet area, relevant hospitals were arranged to conduct physical examinations on the 185 construction workers, all of whom met the requirements for high-altitude operation.

Before the application of the altitude sickness monitoring and evaluation platform for power grid construction workers, according to the survey performed by the High Altitude Sickness Prevention and Control Center of State Grid Corporation of China, the total incidence of acute altitude sickness among construction workers who have just entered the Qinghai-Tibet Plateau was 18.97% while the estimated number of people at risk of altitude sickness is 35. During the one month of monitoring, the platform found that 33 people were assessed to be at risk of altitude sickness. After the medical staff accompanying the team took measures such as providing glucose intake and oxygen therapy for treatment, the conditions of 27 patients were improved, thereby avoiding the occurrence of altitude sickness among power grid construction workers, and only 6 workers suffered from altitude sickness. The comparison is shown in **Table 8**.

Table 8. Comparison of altitude sickness before and after monitoring and evaluation platform application

Serial number	Construction workers/person	Types	Number of patients/person	Prevalence rate/%
1	185	Estimated incidence	35	18.97
2	185	Actual assessment	33	17.84
3	185	After application	6	3.24

From **Table 8**, it can be seen that before the use of altitude sickness prevention platform for power grid construction workers, among the construction team of 185 people, the estimated incidence of altitude sickness was 35 people, and the estimated prevalence rate was 18.97%. Following actual assessment, there were 33 construction workers with symptoms, and the actual prevalence rate was 17.84%. After using the altitude sickness monitoring and evaluation platform for power grid

construction workers, they were evaluated as risky construction workers and treated on-site by medical personnel, with the actual number of patients with altitude sickness to be at 6, and a prevalence rate of 3.24%,signifying a decrease of 14.59% as compared with the method of physical examination beforehand.

8. Conclusions

The altitude sickness monitoring and evalua-

tion platform for power grid construction workers has changed the traditional way of pre-existing physical examination for power grid construction personnel entering Tibet and has realized the transition from altitude sickness treatment of power grid construction personnel to early warning of altitude sickness. The specific implementation of interconnection application reduces the cost of altitude sickness prevention and relief at the construction site, where it not only ensures the health of power grid construction personnel but also improves the efficiency of power grid construction in the Qinghai-Tibet region.

Conflict of interest

The authors declare no conflict of interest.

References

1. Cui J, Yang S. Summary of drug research on improving high altitude working ability (in Chinese). Medical Journal of National Defending Forces in Southwest China 2017; 27(12): 1358–1360.
2. Tian Y, Wang W, Zhang H. An analysis of the incidence and risk factors of acute altitude sickness among visitors to Tibet (in Chinese). Practical Preventive Medicine 2019; 26(8): 975–977.
3. Yuan X, Wu Z, Zha L. The correlation between cardiac function change and sleep quality in patients with chronic mountain sickness in Xining area (in Chinese). Chinese Journal of HealthCare and Medicine 2019; 21(4): 305–308.
4. Liu X, Luo Y. The evolution and the latest progress of the diagnostic criteria of acute mountain sickness (in Chinese). Journal of Preventive Medicine of Chinese People's Liberation Army 2019; 37(10): 188–192.
5. Sun Z, Lin J, Zhu K, et al. Investigation and Analysis on the risk factors of acute high altitude disease in the constructors of high altitude power grid (in Chinese). Medical Journal of National Defending Forces in Southwest China 2016; 26(4): 460–461.
6. Ma S, Shen M, Xia G. Analysis of eight year follow up data of plateau workers by color Doppler echocardiography (in Chinese). Chinese Journal of Industrial Hygiene and Occupational Diseases 2018; 36(8): 607–609.
7. Liu H, Su J, Ma J, et al. The expression of VHL/HIF signaling pathway in the erythroid progenitor cells with chronic mountain sickness (in Chinese). National Medical Journal of China 2019; 99(34): 2670–2674.
8. He X, Feng L, Du Y. Influencing Factors of severe acute mountain sickness (in Chinese). Chinese Journal of Social Medicine 2019; 36(2): 142–145.
9. Wu Y, Bao H, Zhang H. Magnetic resonance and spectrum signal analysis on lumbar vertebra marrow in chronic high altitude disease (in Chinese). Journal of Clinical Radiology 2018; 37(7): 1183–1186.
10. Wang H, Wang D, Yang K. Technical architecture and platform construction of distributed photovoltaic data sharing system based on Internet of Things identification technology (in Chinese). Power System and Clean Energy 2019; 35(8): 69–75.
11. Wang X, Wang L, Wu D, et al. Design about intelligent inspection network scheme of distribution network based on edge calculation and LoRa technologies (in Chinese). Guangdong Electric Power 2020; 33(9): 42–48.
12. Qian H, Jia S, Yang F, et al. Intelligent operation and maintenance technology for relay protection equipment based on mobile Internet (in Chinese). Smart Power 2019; 47(11): 60–66.
13. Ai J, Dang X, Lv Q, et al. Research on full dimension equipment status monitoring system with panoramic function (in Chinese). Power System Protection and Control 2019; 47(16): 122–128.
14. He Y, Liang K, Tan W, et al. Security monitoring system of intelligent substation based on IoT (in Chinese). Telecommunications Science 2018; 34(9): 179–185.
15. Shi Y, Chen C, Luo Y. Design and application of RTU pipeline terminal based on NB-IoT (in Chinese). Transducer and Microsystem Technologies 2019; 38(12): 157–160.
16. Zhang P, Yang M, HE H. Function and application of Internet of Things engine of smart Guangzhou spatiotemporal cloud platform (in Chinese). Geospatial Information 2019; 17(12): 47–49.
17. Zhao N, Wang J, Zhang H, et al. Research and application of remote diagnosis and treatment for cardiovascular diseases based on Internet of Things (in Chinese). China Digital Medicine 2019; 14(12): 80–82.
18. Xie Z, Li D. Research on key technologies of intelligent blood pressure monitoring system based on Internet of Things (in Chinese). China Digital Medicine 2019; 14(12): 36–39.
19. Wang H, Gu S, Wan Y, et al. Research and application of 5G technology in power systems (in Chinese). Guangdong Electric Power 2019; 32(11): 78–85.
20. Konreddy R, He M. How to ensure security in the era of Internet of Things? (in Chinese). Microcontrollers & Embedded Systems 2019; 19(12): 1–3.