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ORIGINAL RESEARCH

Analysis of Factors Influencing the Mental Health Status of Personnel Stationed at High- and Low-Altitude Bases

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Objective: The objective of this study is to investigate and compare the mental health status of personnel stationed at high- and low-altitude bases to provide a reference for future targeted mental health education and support initiatives.

Methods: A total of 1,244 personnel posted in both high- and low-altitude bases were randomly selected using a cluster sampling method. Basic details were collected using a demographic information questionnaire, and their mental health status was assessed using the Symptom Checklist-90 (SCL-90). Statistical analyses included t-tests and Mann–Whitney *U*-tests. Principal component analysis (PCA) based on a Random Forest algorithm was employed to evaluate psychological symptom patterns.

Results: The mental health status of personnel included in this study surpassed the national average for China, with personnel stationed at high-altitude bases reporting better overall mental health than those stationed at low-altitude bases. Among personnel with similar educational backgrounds, those stationed at low-altitude bases had higher levels of interpersonal sensitivity, phobic anxiety, and depressive symptoms than their counterparts stationed at high-altitude bases. Over time in service, the primary psychological issues they experienced shifted from anxiety and paranoia to interpersonal sensitivity, obsessive compulsive disorder, and depression. Additionally, those stationed at low bases with lower incomes reported higher levels of phobic symptoms compared to personnel stationed at high-altitude bases.

Conclusion: In this study, we found that the psychological status of personnel stationed at high- and low-altitude bases was primarily influenced by factors such as income, level of education, years of military service, and geographical location. Measures such as enhancing income and welfare benefits as appropriate, improving education levels by advancing educational opportunities, and providing more mental health education and training may effectively reduce psychological stress and contribute to building a resilient and psychologically healthy military force.

Keywords: altitude, comparative analysis, mental health, personnel, symptom checklist-90, SCL-90

Background

The Kashgar Kunlun Mountains are located in the southwestern part of Xinjiang Uygur Autonomous Region, China, forming a natural geographic boundary and also serving as a significant climatic and ecological convergence zone. This mountainous region has a cold climate, with long, harsh winters and short, cool summers, scarce rainfall, and sparse vegetation, characterized by high-altitude desert grasslands. Given its remote location and relative inaccessibility, the importance of the Kashgar Kunlun Mountains stems not only from the perspective of national defense but also in local infrastructure development such as road construction as well as emergency response efforts like earthquake relief work.

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The region's unique natural and cultural conditions impose considerable challenges for the survival and adaptability of personnel stationed there, placing heightened demands on their physical and psychological resilience. Studies have shown that individuals migrating to extreme high-altitude regions face increased risks of anxiety, depression, and suicidal ideation, with chronic hypoxia exacerbating mood disorders. In addition to geographical and biological factors, socio-economic conditions, culture and educational contexts, and resource accessibility also significantly influence mental health outcomes in these populations.[1] Consequently, the mental health of personnel posted in such high-altitude locations warrants attention. Following the guidelines of the *National Mental Health Work Plan (2016–2020)* and *Opinions on Strengthening the Mental Health of All People in the New Era* issued in 2015 by the Chinese government, research on the mental health of various occupational groups in the country has expanded significantly.

In particular, studies on the mental health of personnel have become increasingly diverse. Numerous researchers, both in China and other countries, have explored mental health issues affecting personnel across different regions, altitudes, and ethnic backgrounds.[2–6] After the coronavirus disease 2019 (COVID-19) pandemic, the National Health Commission of the People's Republic of China and other concerned departments have issued several service guidelines and work plans to address the impact of the pandemic on mental health. The psychological impact, especially with respect to both personnel and civilians, has been a focal point with exploratory studies examining the psychological states, trends, and related impacts on personnel resulting from the pandemic.[7,8]

The Symptom Checklist-90 (SCL-90) developed by Derogatis is a widely utilized scale.[9] It was primarily designed for assessing psychological health in populations such as personnel, healthcare professionals, and students. Encompassing multiple psychological dimensions, the SCL-90 offers a comprehensive evaluation of an individual's psychological symptoms, enabling comparisons and monitoring of changes over time. This scale is suitable for individuals of various ages, genders, and cultural backgrounds. It provides rapid assessment results, facilitating timely interventions. The SCL-90 has garnered widespread recognition and usage globally.[10–12]

In this study, the mental health status of personnel stationed at high- and low-altitude bases was compared and analyzed based on various demographic dimensions. In addition, key factors influencing mental health status were also identified. The aim is to provide a theoretical foundation for enhancing mental health education and psychological support for personnel stationed in training bases.

Data and Methods

General Data

A cluster random sampling method was employed in this study. A total of 1,244 personnel were selected from high- and low-altitude bases between August 2022 and March 2024.

To minimize the influence of individual cultural backgrounds on the experiment, all selected research participants were Han nationality. Given that the duration of exposure to high/low altitude could act as a confounding factor affecting participants' mental health outcomes, all selected subjects were individuals who had been permanently stationed at the same location both during the research project implementation period and prior to its commencement. Therefore, in our study, the exposure period can be equally regarded as their service time.

Personnel stationed at high-altitude bases included 496 soldiers stationed in the Kashgar Kunlun Mountains region at elevations ranging from 4,000 to 5,500 meters. Sixteen respondents were excluded due to non-completion of the questionnaire, resulting in 480 valid questionnaires from the high-altitude group for analysis. Since females soldiers are not stationed in high-altitude areas, all study participants stationed at high-altitude bases were males, aged 19–43 years, with a length of military service ranging 1–24 years. Educational backgrounds were as follows: 84 respondents (34.9%) had an academic senior secondary school diploma or vocational senior secondary school diploma, 135 (56.0%) had a three-year junior college diploma, and 22 (9.1%) had a bachelor's degree or above. With respect to marital status, 329 (68.8%) were unmarried and 149 (31.2%) were married. Income levels were as follows: 23 (12.1%) belonged to the low-income group (no more than RMB 6,000 per month); 101 (53.2%) had a medium-level income (RMB 6,000–12,000 per month), and 66 (34.7%) belonged to the high-income group (above RMB 12,000 per month).

Low-altitude personnel comprised 748 soldiers. Eighteen of them were excluded due to incomplete questionnaires, resulting in 730 valid questionnaires for the low-altitude group. The low-altitude personnel comprised 489 males and 239 females, aged 19–43 years, with a length of military service of 1–24 years. Distribution of educational background: 105 (19.8%) had an academic senior secondary school diploma or vocational senior secondary school diploma; 241 (45.6%) had a three-year junior college diploma; and 183 (34.6%) had a bachelor's degree or above. With respect to marital status, 560 (80.1%) were unmarried and 139 (19.9%) were married. Income levels were as follows: 81 (18.0%) belonged to the low-income group; 276 (61.3%) were in the medium-income group; and 93 (20.7%) were in the high income category.

Due to the limitations of the SCL-90 in capturing contextual factors related to stress and resilience, we conducted in-depth individual interviews with 25 low-altitude base personnel (12 female soldiers, 13 male soldiers) and 25 high-altitude base personnel selected from the 1,244 participants.

The selection of these 25 interviewees was structured to reflect diverse stages of military careers, with the following breakdown:

1. Basic Training Period (High Altitude: 2, Low Altitude: 1)
2. Routine Garrison Period (High Altitude: 12, Low Altitude: 17)
3. Combat Deployment Period (High Altitude: 8, Low Altitude: 1)
4. Career Transition Period (High Altitude: 2, Low Altitude: 3)
5. Pre-Discharge Transition Period (High Altitude: 1, Low Altitude: 3)

This stratification ensures representation across key phases of military service, aligning with theoretical frameworks in career development and adaptation studies.

Study Methods

Survey Tools

The tools used in this study were a personal information questionnaire developed by the research team and the Symptom Checklist-90 (SCL-90), a self-rating symptom scale.[9]

Personal Information Questionnaire

This questionnaire was developed based on demographic variables and tailored to the specific working environment of the personnel being studied. Details that were collected included information on gender, age, marital status, level of education, length of military service, and salary, among other aspects.

Self-Rating Symptom Scale

The Symptom Checklist-90 (SCL-90), a self-rating symptom scale, was used in this study. It is a psychological assessment tool designed to measure the frequency and intensity of various psychological symptoms experienced by an individual over a specific period of time. The scale used in this study is a revised Chinese version of the SCL-90.[13] The scale assesses 10 factors related to emotions, cognition, behavior, and physiological symptoms. There are nine primary subscales (somatization, obsessive-compulsive, interpersonal sensitivity, depression, anxiety, anger-hostility, phobic anxiety, paranoid ideation, and psychoticism), consisting of 90 items to reflect psychological distress. Each item is rated on a 5-point Likert scale, with scores ranging from 0 to 4, as follows: not at all (0 points), a little bit (1 point), moderately (2 points), quite a bit (3 points), and extremely (4 points).

Individual In-Depth Interview Questionnaire

This questionnaire explores income-related contextual factors, including cost-of-living stressors, resource accessibility challenges, and economically impactful events. It also incorporates questions addressing unconventional stressors not captured by current management systems or the SCL-90 standardized scale, alongside scenarios describing critical thresholds of psychological load. The design aims to identify causes of fluctuations in fear-induced stress levels and mental health indicators among stationed soldiers, providing direction for future experimental research.

Survey Methods

The psychological status of the stationed officers and soldiers was assessed collectively, with the testing conducted in a quiet setting strictly adhering to standardized procedures. One to two staff members trained in psychology assisted in conducting the tests. Prior to testing, participants were provided with clear details about the purpose of the test and procedures involved. Each testing session lasted for one hour, and questionnaires were administered and collected on-site. Participants were required to give their responses to the rating scale as per their subjective experiences on the testing day or within the past week.

Statistical Analysis

Data were entered into a database created in Excel, and statistical analyses were performed using SPSS 26.0. t-tests were conducted with a significance level of $\alpha = 0.05$, using two-tailed tests and standard deviation ($\overline{X} \pm S$). Normality tests and tests for homogeneity of variance were conducted prior to analysis. Non-normally distributed data and data exhibiting heterogeneity of variance were subjected to non-parametric tests. Pairwise inter-group comparisons were conducted using the Mann–Whitney *U*-test, while the Kruskal–Wallis *H*-test was used for comparisons among multiple groups. Data showing significant differences in analysis of variance (ANOVA) were subjected to post-hoc pairwise comparisons. Additionally, each psychological symptom was analyzed using principal component analysis (PCA) through interpretable machine learning algorithms, specifically Random Forest and SHapley Additive exPlanations (SHAP) within a Python environment.

Effect Size

Based on the typical effect size of similar studies in the field, we estimate the effect size to be Cohen's d = 0.2 (small effect).[14] We performed a priori power analysis using G*Power 3.1 software, selected ANOVA, and calculated the minimum sample size required to be N = 1,200. The current sample size (N=1,244) is sufficient, with about 3.6% redundancy reserved for potential data loss.

Results

Comparison of SCL-90 Results Between Personnel Stationed at High- and Low-Altitude Bases

The range of average SCL-90 scores for each factor was 1.03–1.18 and 1.05–1.23 points among personnel stationed at high- and low-altitude training bases, respectively. Compared to the national average for China, both groups in this study exhibited significantly higher scores in all the factors, with statistically significant differences ($P < 0.01$) (Table 1).

Regarding the somatization and phobic anxiety scores, there were no significant differences between personnel stationed at high- and low-altitude training bases ($P > 0.05$). In contrast, scores for all the other indicators were significantly higher among personnel stationed at low-altitude training bases than those stationed at high-altitude bases ($P < 0.05$) (Table 2).

Comparison of SCL-90 Scores Between Married and Unmarried Personnel Stationed at High- and Low-Altitude Bases

No significant difference was observed between high- and low-altitude married personnel in any of the scale factors. There were no significant differences between high- and low-altitude unmarried personnel in terms of their somatization and obsessive-compulsive scores, but there were significant differences in all the other factors ($P < 0.05$) (Table 3).

Comparison of SCL-90 Scores Between Personnel with Varying Education Levels at High- and Low-Altitude Station Bases

Personnel stationed at low-altitude bases who had an academic senior secondary school diploma or vocational senior secondary school diploma showed significantly higher scores in interpersonal sensitivity and depression compared to

Table 1 Comparison of SCL-90 Scores of Military Personnel Stationed at High- and Low-Altitude Bases to the Chinese National Standards

Indicator	National Norm	Comparison of SCL-90 Scores of Military Personnel Stationed at High-Altitude Bases to the National Standards			Comparison of SCL-90 Scores of Military Personnel Stationed at Low-Altitude Bases to the National Standards		
		Military Personnel Stationed at High-Altitude Bases (N = 480)	t value	*P*-value	Military Personnel Stationed at Low-Altitude Bases (N = 730)		
Somatization	1.37±0.48	1.14±0.23	−22.81	<0.01	1.14±0.27	−22.29	<0.01
Obsessive-compulsive disorder	1.62±0.58	1.18±0.26	−36.94	<0.01	1.23±0.37	−28.18	<0.01
Interpersonal hypersensitivity	1.65±0.51	1.07±0.19	−65.41	<0.01	1.13±0.43	−32.68	<0.01
Depression	1.50±0.59	1.07±0.19	−50.34	<0.01	1.14±0.43	−22.73	<0.01
Anxiety	1.39±0.43	1.06±0.16	−44.34	<0.01	1.11±0.43	−17.85	<0.01
Hostility	1.48±0.56	1.07±0.17	−53.13	<0.01	1.11±0.28	−36.49	<0.01
Phobic-anxiety	1.23±0.41	1.03±0.15	−28.60	<0.01	1.05±0.17	−28.33	<0.01
Paranoid ideation	1.43±0.57	1.04±0.14	−63.24	<0.01	1.09±0.27	−34.19	<0.01
Psychoticism	1.29±0.42	1.03±0.14	−39.78	<0.01	1.06±0.19	−33.16	<0.01

Table 2 Comparison of SCL-90 Scores Results Between Military Personnel Stationed at High- and Low-Altitude Bases

Comparison of SCL-90 Scores Between Military Personnel Stationed High- and Low-Altitude Bases				
Indicator	Military Personnel Stationed at Low-Altitude Bases	Military Personnel Stationed at High-Altitude Bases	t value	*P*-value
Somatization	1.14±0.27	1.14±0.23	0.92	0.36
Obsessive-compulsive disorder	1.23±0.37	1.18±0.26	2.61	<0.01
Interpersonal hypersensitivity	1.13±0.43	1.07±0.19	2.65	<0.01
Depression	1.14±0.43	1.07±0.19	3.26	<0.01
Anxiety	1.11±0.43	1.06±0.16	2.25	0.02
Hostility	1.11±0.28	1.07±0.17	2.67	<0.01
Phobic-anxiety	1.05±0.17	1.03±0.15	1.90	0.06
Paranoid ideation	1.09±0.27	1.04±0.14	3.66	<0.01
Psychoticism	1.06±0.19	1.03±0.14	2.67	<0.01

their high-altitude counterparts with an academic senior secondary school diploma or vocational senior secondary school diploma. These two groups showed no significant difference in the other SCL-90 factors.

Low-altitude personnel with a three-year junior college diploma had significantly higher scores in interpersonal sensitivity and phobic anxiety in comparison to high-altitude personnel with a three-year junior college diploma. There were no significant differences in the other scale factors.

Among personnel stationed at low- and high-altitude bases holding a bachelor's degree or above, there was no significant difference in SCL-90 scores between these two groups across all the scale factors (Table 4).

As shown by Kruskal–Wallis *H*-tests, except for those of somatization and interpersonal sensitivity, there was a significant difference in the medians (P25, P75) of all the other factors among personnel stationed at low-altitude bases with an academic senior secondary school diploma or vocational senior secondary school diploma, those with a three-year junior college diploma, and those with a bachelor's degree or above ($P < 0.05$). These factors with significant differences were subsequently subjected to post-hoc pairwise comparisons, which revealed that personnel stationed at

Table 3 Comparison of SCL-90 Scores of Married and Unmarried Military Personnel Stationed High- and Low-Altitude Bases

Indicator	Area	Unmarried					Married				
		N	Average Rank	Sum of Ranks	Z value	P value	N	Average Rank	Sum of Ranks	Z value	P value
Somatization	Low-altitude	560	447.42	250,553.50	−0.40	0.69	139	142.89	19,862.00	−0.33	0.74
	High-altitude	329	440.89	145,051.50			149	146.00	21,754.00		
Obsessive-compulsive disorder	Low-altitude	561	452.66	253,940.00	−1.15	0.25	139	146.27	20,331.50	−0.36	0.72
	High-altitude	329	433.30	142,555.00			149	142.85	21,284.50		
Interpersonal hypersensitivity	Low-altitude	561	460.78	258,496.00	−2.83	0.01	139	152.67	21,221.50	−2.07	0.04
	High-altitude	329	419.45	137,999.00			149	136.88	20,394.50		
Depression	Low-altitude	561	459.96	258,037.00	−2.64	0.01	139	149.95	20,843.00	−1.22	0.22
	High-altitude	329	420.84	138,458.00			149	139.42	20,773.00		
Anxiety	Low-altitude	561	462.07	259,219.50	−3.09	<0.01	139	146.97	20,429.00	−0.59	0.56
	High-altitude	329	417.25	137,275.50			149	142.19	21,187.00		
Hostility	Low-altitude	561	459.30	257,669.50	−2.82	0.01	139	145.10	20,169.00	−0.14	0.89
	High-altitude	329	421.96	138,825.50			149	143.94	21,447.00		
Phobic-anxiety	Low-altitude	561	455.91	255,766.50	−2.58	0.01	139	149.22	20,741.50	−1.58	0.11
	High-altitude	329	427.75	140,728.50			149	140.10	20,874.50		
Paranoid ideation	Low-altitude	561	456.14	255,897.00	−2.41	0.02	139	149.76	20,817.00	−1.53	0.13
	High-altitude	329	427.35	140,598.00			149	139.59	20,799.00		
Psychoticism	Low-altitude	561	459.36	257,700.00	−3.12	<0.01	139	149.88	20,833.00	−1.66	0.10
	High-altitude	329	421.87	138,795.00			149	139.48	20,783.00		

low-altitude bases with a bachelor's degree or above exhibited significant differences in these factors in comparison to those stationed at low-altitude bases with lower educational qualifications ($P < 0.05$).

For personnel stationed at high-altitude bases, there were significant differences in depression and hostility scores across educational levels ($P < 0.01$), while there were no significant differences in all the other SCL-90 factors. Post-hoc tests indicated that personnel with a bachelor's degree or above differed significantly in depression scores compared to those with an academic or vocational senior secondary school diploma and in hostility scores compared to both personnel with an academic or vocational senior secondary school diploma and those with a three-year junior college diploma (Appendix Table 1).

Comparison of SCL-90 Scores Between Personnel Stationed at High- and Low-Altitude Bases with Varying Years of Military Service

Personnel stationed at low- and high-altitude bases exhibited varying SCL-90 scores across years of service. Personnel with less than 5 years of military service exhibited significant differences in anxiety, paranoid ideation, and psychoticism, with no significant difference in the other SCL-90 factors. Personnel stationed at low-altitude bases with 6–10 years of military service exhibited a significant difference only in depression, while personnel with 11–15 years of military service exhibited significantly higher scores in interpersonal sensitivity and phobic-anxiety compared to those stationed at high-altitude bases with similar duration of military service ($P < 0.01$). There were no significant differences across all factors among personnel with more than 15 years of military service stationed at low- and high-altitude bases (Table 5).

With respect to high-altitude personnel, their duration of military service was associated with significant differences in three factors: obsessive-compulsive, depression, and phobic-anxiety, while there were no significant differences in all the other factors. Post-hoc tests on these three statistically significant factors further revealed that personnel with less than 5 years of military service and 11–15 years of military service exhibited significant differences in depression and phobic-anxiety. Personnel with 6–10 years of military service and more than 15 years of military service exhibited significant differences in obsessive-compulsive, depression, and phobic-anxiety factors. Personnel with less than 5 years of military service and 6–10 years of military service exhibited a significant difference in only one SCL-90 factor, that is, depression (Appendix Table 2).

Table 4 Comparison of SCL-90 Scores Between Military Personnel with Varying Education Levels Stationed at High- and Low-Altitude Bases

Indicator	Area	Academic Senior Secondary School Diploma or Vocational Senior Secondary School Diploma					Three-Year Junior College Diploma					Bachelor's Degree or Above				
		N	Average Rank	Sum of Ranks	Z value	P value	N	Average Rank	Sum of Ranks	Z value	P value	N	Average Rank	Sum of Ranks	Z value	P value
Somatization	Low-altitude	105	96.05	10,085.50	−0.32	0.75	240	180.54	43,330.50	−1.88	0.06	183	102.44	18,747.00	−0.41	0.68
	High-altitude	84	93.68	7869.50			135	201.26	27,169.50			22	107.64	2368.00		
Obsessive-compulsive disorder	Low-altitude	105	98.24	10,315.00	−0.99	0.32	241	191.29	46,100.50	−0.70	0.48	183	103.54	18,948.00	−0.39	0.70
	High-altitude	84	90.95	7640.00			135	183.52	24,775.50			22	98.50	2167.00		
Interpersonal hypersensitivity	Low-altitude	105	102.09	10,719.00	−2.63	0.01	241	196.48	47,352.50	−2.44	0.02	183	103.82	18,999.00	−0.65	0.52
	High-altitude	84	86.14	7236.00			135	174.25	23,523.50			22	96.18	2116.00		
Depression	Low-altitude	105	101.77	10,686.00	−2.40	0.02	241	188.13	45,339.50	−0.11	0.91	183	103.84	19,002.00	−0.63	0.53
	High-altitude	84	86.54	7269.00			135	189.16	25,536.50			22	96.05	2113.00		
Anxiety	Low-altitude	105	98.92	10,387.00	−1.46	0.15	241	192.50	46,391.50	−1.20	0.23	183	103.05	18,857.50	−0.04	0.97
	High-altitude	84	90.10	7568.00			135	181.37	24,484.50			22	102.61	2257.50		
Hostility	Low-altitude	105	98.74	10,367.50	−1.42	0.16	241	190.31	45,865.50	−0.59	0.55	183	102.30	18,720.00	−0.57	0.57
	High-altitude	84	90.33	7587.50			135	185.26	25,010.50			22	108.86	2395.00		
Phobic-anxiety	Low-altitude	105	97.35	10,221.50	−1.33	0.18	241	194.11	46,779.50	−2.37	0.02	183	104.00	19,031.50	−0.96	0.34
	High-altitude	84	92.07	7733.50			135	178.49	24,096.50			22	94.70	2083.50		
Paranoid ideation	Low-altitude	105	98.93	10,388.00	−1.82	0.07	241	190.91	46,009.00	−0.90	0.37	183	104.90	19,197.50	−1.75	0.08
	High-altitude	84	90.08	7567.00			135	184.20	24,867.00			22	87.16	1917.50		
Psychoticism	Low-altitude	105	97.55	10,242.50	−1.24	0.22	241	191.10	46,054.50	−1.04	0.30	183	104.73	19,165.50	−1.59	0.11
	High-altitude	84	91.82	7712.50			135	183.86	24,821.50			22	88.61	1949.50		

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Table 5 Comparison of SCL-90 Scores Between Military Personnel with Varying Years of Military Service Stationed at High- and Low-Altitude Bases

Indicator	Area	Less than 5 Years					6–10 Years					11–15 Years					More than 15 Years				
		N	Average Rank	Sum of Ranks	Z value	P value	N	Average Rank	Sum of Ranks	Z value	P value	N	Average Rank	Sum of Ranks	Z value	P value	N	Average Rank	Sum of Ranks	Z value	P value
Somatization	Low-altitude	434	319.80	138,792.00	−0.04	0.97	158	152.97	24,169.00	−0.23	0.82	86	84.20	7241.00	−0.09	0.93	50	44.94	2247.00	−0.99	0.32
	High-altitude	205	320.43	65,688.00			149	155.09	23,109.00			82	84.82	6955.00			44	50.41	2218.00		
Obsessive-compulsive disorder	Low-altitude	435	318.90	138,723.00	−0.34	0.74	158	162.16	25,622.00	−1.78	0.08	86	86.73	7458.50	−0.63	0.53	50	44.95	2247.50	−0.99	0.32
	High-altitude	205	323.89	66,397.00			149	145.34	21,656.00			82	82.16	6737.50			44	50.40	2217.50		
Interpersonal hypersensitivity	Low-altitude	435	326.60	142,073.00	−1.49	0.14	158	161.44	25,507.00	−1.92	0.06	86	92.30	7938.00	−2.69	0.01	50	49.91	2495.50	−1.08	0.28
	High-altitude	205	307.55	63,047.00			149	146.11	21,771.00			82	76.32	6258.00			44	44.76	1969.50		
Depression	Low-altitude	435	324.28	141,063.00	−0.89	0.38	158	164.31	25,961.50	−2.81	0.01	86	88.37	7600.00	−1.21	0.23	50	46.28	2314.00	−0.49	0.62
	High-altitude	205	312.47	64,057.00			149	143.06	21,316.50			82	80.44	6596.00			44	48.89	2151.00		
Anxiety	Low-altitude	435	328.78	143,018.00	−2.01	0.04	158	159.09	25,135.50	−1.36	0.18	86	89.06	7659.00	−1.51	0.13	50	47.55	2377.50	−0.02	0.98
	High-altitude	205	302.94	62,102.00			149	148.61	22,142.50			82	79.72	6537.00			44	47.44	2087.50		
Hostility	Low-altitude	435	326.49	142,023.50	−1.61	0.11	158	158.78	25,088.00	−1.36	0.18	86	87.63	7536.00	−1.06	0.29	50	46.33	2316.50	−0.49	0.63
	High-altitude	205	307.79	63,096.50			149	148.93	22,190.00			82	81.22	6660.00			44	48.83	2148.50		
Phobic-anxiety	Low-altitude	435	324.56	141,185.00	−1.26	0.21	158	157.56	24,895.00	−1.45	0.15	86	90.08	7747.00	−2.60	0.01	50	47.99	2399.50	−0.28	0.78
	High-altitude	205	311.88	63,935.00			149	150.22	22,383.00			82	78.65	6449.00			44	46.94	2065.50		
Paranoid ideation	Low-altitude	435	327.65	142,529.00	−2.10	0.04	158	155.64	24,591.50	−0.54	0.59	86	87.73	7545.00	−1.32	0.19	50	49.38	2469.00	−0.98	0.33
	High-altitude	205	305.32	62,591.00			149	152.26	22,686.50			82	81.11	6651.00			44	45.36	1996.00		
Psychoticism	Low-altitude	435	329.13	143,171.50	−2.46	0.01	158	157.66	24,911.00	−1.33	0.18	86	87.16	7496.00	−1.22	0.22	50	48.91	2445.50	−0.70	0.49
	High-altitude	205	302.19	61,948.50			149	150.11	22,367.00			82	81.71	6700.00			44	45.90	2019.50		

Comparison of SCL-90 Scores of Personnel with Varying Income Levels Stationed at High- and Low-Altitude Bases

Personnel stationed at high- and low-altitude bases showed significant differences in SCL-90 scores when analyzed by income levels. Among personnel with low income, significant differences in phobic-anxiety scores were observed, while there were no significant differences in all the other factors. Personnel with a medium income level stationed at high- and low-altitude bases exhibited statistically significant differences in interpersonal sensitivity, hostility, phobic-anxiety, and psychoticism. There were no significant differences in any of the SCl-90 factors among those with high income stationed at high- and low-altitude bases (Table 6).

The analysis of SCL-90 cores across income groups in personnel stationed at high-altitude stations revealed that the low-, medium-, and high-income groups differed significantly in interpersonal sensitivity and hostility scores. Post hoc tests indicated significant differences in interpersonal sensitivity and hostility between personnel in the medium-income and low-income groups, stationed at high-altitude bases, as well as between medium-income and high-income groups stationed at high-altitude bases. Personnel in medium-income and high-income groups stationed at high-altitude bases exhibited a statistically significant difference only in hostility scores (Appendix Table 3).

Comparison of SCL-90 Scores in Personnel of Different Genders Stationed at High- and Low-Altitude Bases

Due to the unique geographical conditions and deployment tasks in high-altitude regions, only male personnel were stationed in these regions, limiting our gender comparisons to only those stationed at low-altitude bases. Among those stationed at low-altitude bases, female personnel had significantly higher scores in three factors, namely, depression, anxiety, and psychoticism, in comparison to male personnel (all $P < 0.05$). This suggests statistically significant gender-based differences in depression, anxiety, and psychoticism factors in the SCL-90 scale. No significant differences were observed in the other factors between male and female personnel stationed at low-altitude bases (Table 7).

Principal Component Analysis of Factors Influencing Mental Health

A principal component analysis of the nine primary factors influencing mental health was conducted using Random Forest analysis based on SCL-90 data. Income, level of education, and years of service were identified as having the most significant impact on the mental health of personnel. Other variables such as geographical location, gender, and marital status, did not exert a significant influence. However, among the other factors, geographical location emerged as being the most strongly associated with variations in depression levels in personnel (Figure 1).

Discussion

In this study, our results revealed that, overall, personnel stationed in both high- and low-altitude bases had higher mental health factor scores than the Chinese national norm, reflecting better mental health. Specifically, the number of positive items and scores relating to obsessive-compulsive, interpersonal relationships, depression, hostility, paranoid ideation, and psychoticism were significantly lower in personnel stationed at high-altitude bases than those stationed at low-altitude bases. This indicates a better overall mental health status among personnel in the high-altitude group. This result is contrary to the findings of Wenrong, Ortiz-Prado, E. et al.[5,15] The differences in the outcomes in this study can be attributed to the significant improvements over the past decade in living standards and quality of life in military bases located in high-altitude areas.[16] However, these benefits usually were not accessible to civilians. Therefore, these contradictions in findings may reveal the possible pathways for reducing suicide rate for people at or moving to high altitude areas.[1]

First of all, the cost of living and inflation rate at high-altitude areas were much smaller than that in low-altitude areas, which alleviate the stress for soldiers at high-altitude areas. According to personal in-depth interviews, high-altitude military personnel typically undergo phased adaptation training (graded at 2,500 m, 3,000 m, and 4,000 m). Combined with daily low-flow oxygen inhalation (1–2 L/min) to maintain blood oxygen levels, this approach effectively reduces chronic hypoxia-induced cerebral metabolic disorders, thereby alleviating anxiety, depression, and related emotional

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Table 6 Comparison of SCL-90 Scores Between Military Personnel with Varying Income Levels Stationed High- and Low-Altitude Bases

Indicator	Area	Low Income (Less than RMB 6,000)					Medium Income (RMB 6,000–RMB 12,000)					High Income (More than RMB 12,000)				
		N	Average Rank	Sum of Ranks	Z value	P value	N	Average Rank	Sum of Ranks	Z value	P value	N	Average Rank	Sum of Ranks	Z value	P value
Somatization	Low-altitude	81	53.85	4362.00	−0.91	0.36	276	187.41	51,726.50	−0.50	0.62	93	75.44	7016.00	−1.54	0.12
	High-altitude	23	47.74	1098.00			101	193.33	19,526.50			66	86.42	5704.00		
Obsessive-compulsive disorder	Low-altitude	81	55.35	4483.50	−1.86	0.06	276	194.39	53,652.00	−1.70	0.09	93	79.72	7413.50	−0.10	0.92
	High-altitude	23	42.46	976.50			101	174.27	17,601.00			66	80.40	5306.50		
Interpersonal hypersensitivity	Low-altitude	81	53.73	4352.50	−0.87	0.38	275	197.08	54,197.00	−3.39	<0.01	93	82.64	7685.50	−1.04	0.30
	High-altitude	23	48.15	1107.50			101	165.14	16,679.00			66	76.28	5034.50		
Depression	Low-altitude	81	55.17	4469.00	−1.82	0.07	276	193.61	53,436.50	−1.71	0.09	93	81.53	7582.00	−0.58	0.56
	High-altitude	23	43.09	991.00			101	176.40	17,816.50			66	77.85	5138.00		
Anxiety	Low-altitude	81	55.03	4457.50	−1.80	0.07	276	194.00	53,545.00	−1.90	0.06	93	80.48	7485.00	−0.19	0.85
	High-altitude	23	43.59	1002.50			101	175.33	17,708.00			66	79.32	5235.00		
Hostility	Low-altitude	81	54.25	4394.00	−1.31	0.19	276	194.24	53,609.50	−2.15	0.03	93	79.31	7375.50	−0.27	0.79
	High-altitude	23	46.35	1066.00			101	174.69	17,643.50			66	80.98	5344.50		
Phobic-anxiety	Low-altitude	81	55.19	4470.00	−2.35	0.02	276	193.79	53,486.50	−2.59	<0.01	93	81.10	7542.00	−0.59	0.55
	High-altitude	23	43.04	990.00			101	175.91	17,766.50			66	78.45	5178.00		
Paranoid ideation	Low-altitude	81	54.97	4452.50	−1.99	0.05	276	193.17	53,315.50	−2.00	0.05	93	81.92	7619.00	−0.96	0.34
	High-altitude	23	43.80	1007.50			101	177.60	17,937.50			66	77.29	5101.00		
Psychoticism	Low-altitude	81	53.93	4368.00	−1.25	0.21	276	193.26	53,339.00	−2.21	0.03	93	83.45	7760.50	−1.67	0.10
	High-altitude	23	47.48	1092.00			101	177.37	17,914.00			66	75.14	4959.50		

Table 7 Comparison of SCL-90 Scores Between Military Personnel of Different Genders Stationed at High- and Low-Altitude Bases

Indicator	Gender	Case Number	Average Rank	Sum of Ranks	Z value	P value
Somatization	Male	489	370.82	181,333.00	−1.25	0.21
	Female	239	351.56	84,023.00		
Obsessive-compulsive disorder	Male	490	360.62	176,703.00	−0.85	0.39
	Female	239	373.98	89,382.00		
Interpersonal hypersensitivity	Male	490	358.58	175,704.00	−1.40	0.16
	Female	239	378.16	90,381.00		
Depression	Male	490	355.19	174,043.00	−2.102	0.04
	Female	239	385.11	92,042.00		
Anxiety	Male	490	355.26	174,077.50	−2.14	0.03
	Female	239	384.97	92,007.50		
Hostility	Male	490	364.24	178,476.50	−0.18	0.86
	Female	239	366.56	87,608.50		
Phobic-anxiety	Male	490	358.66	175,743.50	−1.80	0.07
	Female	239	378.00	90,341.50		
Paranoid ideation	Male	490	362.57	177,658.50	−0.64	0.52
	Female	239	369.99	88,426.50		
Psychoticism	Male	490	356.82	174,839.50	−2.13	0.03
	Female	239	381.78	91,245.50		

issues.[17] Snow-capped mountains and wilderness landscapes alleviate stress through the "Attention Restoration Theory (ART)", with some military personnel reporting that the tranquility of natural environments can offset 30–40% of physiological discomfort. Studies indicate that exposure to natural scenery leads to an average 15% reduction in cortisol

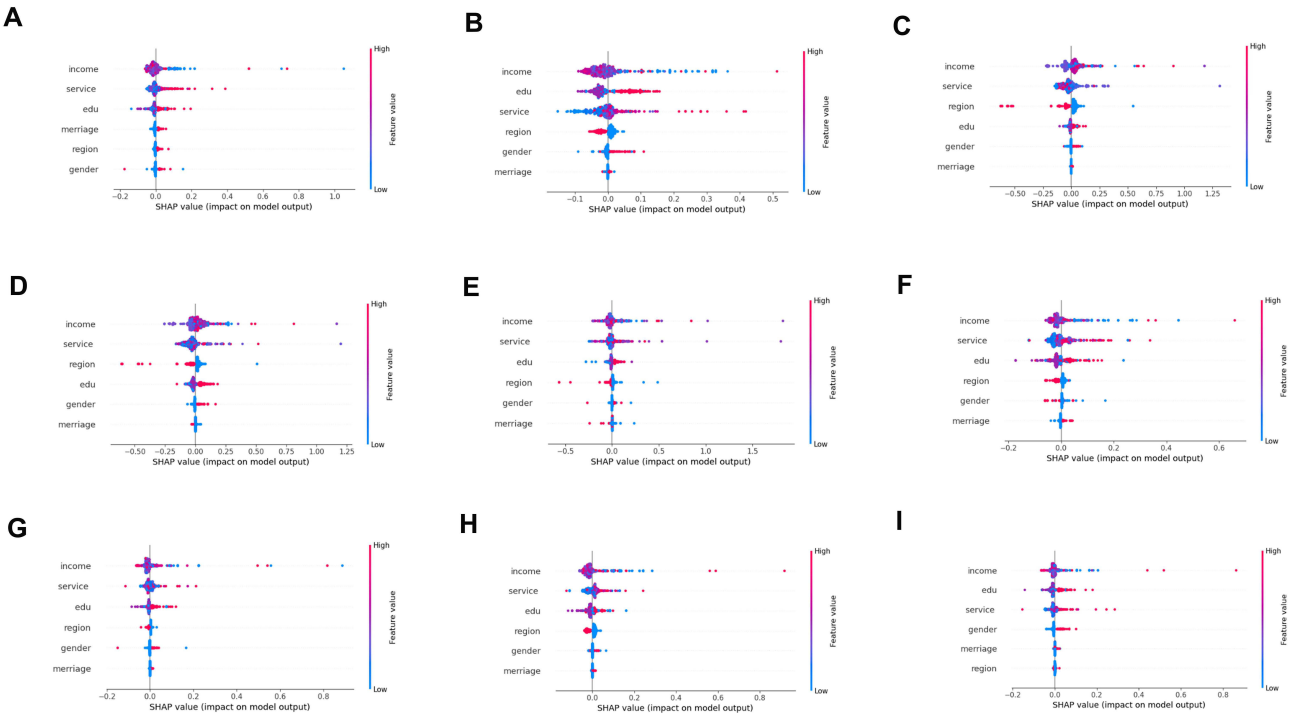

Figure 1 Results of PCA of factors influencing the mental health of military personnel based on random forest and SHAP interpretable algorithms. Each graph represents the impact strength of different factors on a specific mental health factor. Income: income level. Service: years of military service. Edu: education level. Region: geographical region. Gender: gender. Marriage: marital status. (**A**) Somatization. (**B**) Obsessive-compulsive disorder. (**C**) Interpersonal hypersensitivity. (**D**) Depression. (**E**) Anxiety. (**F**) Hostility. (**G**) Phobic-anxiety. (**H**) Paranoid ideation. (**I**) Paranoid ideation.

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levels.[18] Additionally, the remote geographical location of high-altitude bases fosters a "community effect", increasing collaborative demands among members by over 50%. For instance, research on Antarctic research stations demonstrates that collectively confronting extreme challenges can elevate team cohesion scores by 32%, significantly buffering psychological issues caused by isolation.[19]

Furthermore, the three years of the pandemic had a relatively lesser impact on personnel stationed at high-altitude bases, while posing heavier demands, in terms of military tasks, on personnel stationed at low-altitude bases. In addition, significant changes have been introduced in the living conditions and stationing responsibilities of personnel, contributing to differing levels of stress responses among them. For personnel stationed at high-altitude bases, garrison tasks remain stable and well-defined. In contrast, personnel stationed at low-altitude bases encounter challenges in terms of increased workloads, complexity, greater management rigor and training intensity, which have been intensified by recent global instability and a shifting international landscape. These macro-level factors may have likely increased the psychological stress on personnel stationed at low-altitude bases. In addition, the stabilization of conditions in Xinjiang in recent years has gradually decreased stress levels among personnel. Dedicated efforts over the past decade to enhance psychological support and mental health education among personnel stationed at high-altitude bases have also yielded significant improvements in their mental health status.

The comparison between married and unmarried personnel revealed that married personnel stationed at low-altitude bases exhibited a significantly worse status only in interpersonal sensitivity in comparison to those stationed at high-altitude bases. In contrast, personnel stationed at low-altitude bases who were unmarried had significantly higher scores in interpersonal sensitivity, depression, anxiety, hostility, phobic-anxiety, paranoid ideation, and psychoticism in comparison to their counterparts stationed at high-altitude bases. This indicates that unmarried personnel stationed at low-altitude bases had a significantly lower level of mental health compared to those stationed at high-altitude bases and that personnel who were married had a more stable mental health status.

Marital status has a significant impact on an individual's overall life satisfaction, including environmental and economic satisfaction, and especially satisfaction in interpersonal relationships.[20] These feelings of happiness and satisfaction are directly related to mental health outcomes. Low-altitude regions typically have a denser presence of personnel and more complex social and family structures. Married individuals in particular face more challenges and demands in their daily social interactions and dynamics, thereby increasing their sensitivity to interpersonal relationships. However, marriage provides a critical support network that can help individuals cope with risks, providing emotional and economic stability, and reducing feelings of loneliness, anxiety, and depression.[21,22] On the other hand, a significant number of unmarried servicemen experience feelings of loss and sadness from having to end existing relationships due to enlistment. Therefore, compared to personnel stationed at high-altitude bases who operate within simpler social structures, unmarried personnel stationed at low-altitude bases show a greater need for psychological education and counseling.

We analyzed the impact of education levels, reflecting individuals' academic attainment, on the mental health status of personnel stationed at high-altitude and low-altitude bases. Our findings revealed that personnel stationed at low-altitude bases with an academic senior secondary school diploma or vocational secondary school diploma (lower education level) had significantly higher scores in interpersonal sensitivity and depressive symptoms in comparison with those stationed at high-altitude bases with similar levels of education. Personnel stationed at low-altitude bases with a three-year junior college diploma (intermediate education level) had significantly higher scores in interpersonal sensitivity and phobic-anxiety in comparison to personnel stationed at high-altitude bases with similar education. However, there were no significant differences between personnel with a bachelor's degree or above (higher education level) stationed at low-altitude and high-altitude bases. Moreover, personnel with a higher education level, stationed at both high- and low-altitude bases, had higher scores on factors reflecting mental health challenges in comparison to those with lower educational backgrounds in the same area. These findings are consistent with the conclusions of Anxin and Guiqing,[23,24] as well as Xiuyun.

This pattern can be attributed to several factors. The influence of different military career stages was actually closely related to education levels. Individuals with lower education levels generally lack mental health literacy and coping skills, making them more prone to negative emotional cycles when facing stress. Studies have shown that those with less formal education tend to adopt avoidant coping strategies (eg, emotional suppression, denial), while individuals with higher education levels are more adept at employing active problem-solving strategies or seeking social support.[17]

Qualitative interviews revealed that in isolated high-altitude facilities, individuals with lower education levels predominantly engage in highly repetitive and low-autonomy roles (eg, equipment maintenance, logistical support). Prolonged mechanized labor in such settings increases vulnerability to emotional exhaustion. In contrast, those with advanced education are more likely to occupy managerial or technical positions, where job satisfaction and a sense of accomplishment act as psychological buffers against environmental stressors. Additionally, high-altitude bases often adopt hierarchical management systems. Highly-educated personnel typically occupy central positions in information networks, facilitating the establishment of both horizontal (peer) and vertical (superior) support relationships. In contrast, grassroots-level staff tend to have more insular social circles. Particularly among those with limited verbal communication skills, negative emotions are prone to form "emotional resonance" within homogeneous groups.[19]

Higher education levels are often accompanied by intense academic pressure and highly competitive environments.[25] Through personal in-depth interviews, it is found that higher education personnel have more opportunities to adjust their positions, which brings more challenges and pressures, and learning new knowledge, adapting to and performing higher-risk tasks have become the main sources of staying up late, anxiety, hostility, and exhaustion. Furthermore, personnel on training missions may find it difficult to balance their pursuit of personal career aspirations with their mission duties, leading to internal conflict. Higher educational attainments are marked by an increase in cognitive complexity and critical thinking, making individuals more prone to prolonged states of anxiety and depression due to their more intense processing of stressors.

Our analysis of the impact of duration of military service on the mental health status of personnel revealed distinct trends among those stationed at low- and high-altitude bases. Overall, personnel stationed at low-altitude bases showed changes in different mental health factors with increasing duration of military service, while those stationed at high-altitude bases did not show such marked shifts. Specifically, with respect to low-altitude bases, personnel with less than 5 years of military service experienced significantly higher levels of anxiety, paranoid ideation, and psychoticism. Those with 6–10 years of military service exhibited more pronounced depressive symptoms in comparison to personnel stationed at high-altitude bases. Personnel stationed at low-altitude bases with 11–15 years of military service had higher scores of interpersonal sensitivity and phobic-anxiety compared to their peers stationed at high-altitude bases. Personnel with more than 15 years of military service across both altitudes did not exhibit any significant differences in overall mental health status.

Despite this, veterans with more than 15 years of military service stationed at high-altitude bases showed significantly more pronounced obsessive-compulsive and depressive symptoms in comparison to those with shorter service durations stationed at high-altitude bases. Veterans stationed at low-altitude bases primarily reported more hostility in comparison to those with shorter military service.

Several factors may contribute to this trend of results. New recruits require a period of time to adapt to the regimented military lifestyle, unfamiliar environments, and strict discipline, among other aspects, which can trigger psychological stress and anxiety. The rigidity of prior habits, behavioral, and cognitive patterns may also cause internal conflicts or deviant behaviors during this adaptation period.[26] As they gain more service experience, personnel gradually develop clarity in their career paths and expectations, leading to a sense of inner security derived from their professional stability. However, longer service time is accompanied by more complex challenges in terms of interpersonal relationships and social arrangements, such as separation from family, child-rearing, and elder care. This can lead to internal conflicts among veteran soldiers as they struggle to balance personal and professional responsibilities.[27] Veterans with more than 15 years of military service stationed at high-altitude bases face a higher likelihood of combat exposure, increasing their susceptibility to psychological disturbances.

We found significant differences when we compared personnel with varying income levels across low- and high-altitude bases. Personnel with a lower income level (no more than RMB 6,000 per month) stationed at low-altitude training bases had significantly higher phobic-anxiety scores in comparison to high-altitude personnel with the same income level. Those with a medium income level (RMB 6,000–12,000 per month) stationed at low-altitude bases reported significantly higher scores of interpersonal sensitivity, hostility, phobic-anxiety, and psychoticism in comparison to personnel with a medium income level stationed at high-altitude bases. High-income personnel (more than RMB

12,000 per month), stationed at both low- and high-altitude bases, exhibited no significant difference in mental health levels.

A crucial factor contributing to these disparities is the contrasting economic environments between low- and high-altitude places. Life at high altitudes is characterized by a relatively frugal lifestyle associated with lower costs, while living at low altitudes involves higher expenses, often creating a sense of economic disparity among personnel with lower incomes who may perceive a gap in material wealth compared to their surroundings. This perception may lead to intensified feelings of economic disadvantage and stress, followed by a series of psychological impacts such as worry, phobia, and anxiety about social relationships and future career development.

Further analysis revealed that personnel with a medium income level stationed at low-altitude bases demonstrated better overall mental health, except for somatization and psychoticism, when compared to their peers with low incomes. Those with a medium income level stationed at high-altitude bases had significantly lower interpersonal sensitivity scores in comparison to those with low and high incomes stationed at high-altitude bases. Personnel with high incomes stationed at high altitudes exhibited significantly higher hostility scores in comparison to those with medium and low incomes stationed at high-altitude bases.

A possible contributing factor for this trend is the relative stability in the perception of their socioeconomic status among personnel with a medium income level. Unlike those with lower incomes who may focus more on upward mobility, individuals in the medium-income group are less likely to feel the constant drive for achievement. They are not as concerned as those from lower-income groups about improving their social status, nor are they as worried as those from higher-income groups about retaining their status. According to the social comparison theory, individuals tend to evaluate their abilities and social standing by comparing themselves to others in their social environment.[24] This framework helps explain the mental health differences observed among personnel with varying income levels stationed at high altitudes. Personnel with medium income levels stationed at high-altitude bases often operate within a relatively homogeneous social circle, reducing their exposure to marked socioeconomic contrasts. Consequently, they may experience less comparative pressure, which correlates with lower levels of interpersonal sensitivity. In contrast, personnel from low- and high-income groups, situated at either end of the socioeconomic spectrum, are more susceptible to comparisons with various social strata, intensifying social sensitivity in their interactions.

On this basis, the content of in-depth personal interviews also supports this result in more detail. Typically, in the low altitude area, the cost of living, including housing, medical care, marriage management and education for kids, was much higher than that in the high altitude area. Therefore, although income is still the major influencing factor, its impact on soldiers in high and low altitude were different. The impact of income on soldiers in low altitude was less prominent than in high altitude. As income increase in low altitude area could be compromised by the rapid inflation. While inflation in high altitude was much slower. Of all the interviewees, all have picked housing and medical care as the two most costly events. However, due to different inflation rate in high and low altitude areas. Soldiers in high altitude were less stressful than soldiers in low altitude areas, which was the same as the outcome of SCL-90.

The gender comparison revealed that female personnel reported significantly higher levels of depression, anxiety, and psychoticism compared to their male counterparts. This disparity can be partly attributed to gender differences in the distribution and function of cerebral neurotransmitters. Such differences affect hormone levels, emotion regulation, and stress responses. Women are more likely to adopt internalizing coping mechanisms such as suppression and self-blame to deal with stress and emotional issues, which are less effective than externalizing coping strategies, thus increasing the likelihood of their developing depressive and anxiety symptoms.

Additionally, high-intensity military training can impose physical and psychological stress on female soldiers, leading to heightened stress responses. The physical demands, coupled with menstrual disorders, can lead to endocrine imbalances, which can exacerbate negative emotions.[28] Furthermore, female soldiers may encounter more role limitations and career development barriers within the military, potentially leading to frustration and dissatisfaction, as well as increasing the risk of depression and psychoticism.[29]

Principal component analysis revealed that income level was the primary factor influencing mental health among personnel, with duration of military service and level of education emerging as key determinants, particularly affecting somatization, interpersonal sensitivity, depression, anxiety, hostility, phobic-anxiety, and paranoid ideation. Geographical

location exerted a significant influence on interpersonal sensitivity and depression, whereas gender and marital status had relatively minor effects on the mental health status of personnel.

This analysis in this study was based on the simulation of different individual characteristics using the Random Forest machine learning algorithm, offering insights with moderate reference value. Findings suggest that increasing income and educational attainment of individuals could significantly influence their psychological wellbeing. Moreover, mental health status was dynamic and changed with variations in years of service and geographical location. A higher income or educational attainment did not necessarily guarantee better mental health. Instead, these factors were associated with different psychological challenges. Overall, increased income levels and educational attainment may alleviate most negative emotions,[30] though psychological effects induced by changes in geographical location or prolonged military service are variable and require regular monitoring and periodic assessment for a comprehensive understanding of mental health trends in this population.

Conclusion

This study presents the first comprehensive analysis of the mental health of personnel stationed at high- and low-altitude bases, based on a comprehensive large-scale survey involving 480 personnel stationed at high-altitude bases and 730 stationed at low-altitude bases. We used the SCL-90 scale to assess and compare the mental health status of personnel stationed at high- and low-altitude bases. In addition, 25 high-altitude base garrisons and 25 low-altitude base garrisons were selected among the research subjects for in-depth personal interviews. The aim of this study was to explore the unconventional stressors that the SCL-90 standard scale failed to respond to and the reasons that led to the fluctuation of fear stress levels and mental health indicators of garrison soldiers, so as to point out the direction for further experimental research in the future.

Our results revealed that the overall mental health levels of all participants exceeded the national norm for China, with personnel at high-altitude bases displaying superior mental well-being compared to their counterparts stationed at low-altitude bases.

Personnel who were married and stationed at low-altitude bases exhibited significantly higher levels of interpersonal sensitivity compared to those stationed at high-altitude bases. Furthermore, being married itself appeared beneficial to psychological well-being, with married individuals reporting better mental health in comparison to their unmarried counterparts.

The levels of education also played an influential role: personnel stationed at low-altitude bases, irrespective of educational background, exhibited significantly higher levels of interpersonal sensitivity, phobic-anxiety, and depressive symptoms in comparison to those stationed at high-altitude bases. Personnel with higher education levels across both altitudes exhibited more psychological issues. The psychological concerns of personnel stationed at low-altitude bases differed from those stationed at high-altitude bases.

New recruits were more prone to anxiety and paranoid ideations. With longer durations of military service, interpersonal sensitivity, obsessive-compulsive, and depression symptoms increased.

Personnel with lower incomes stationed at low-altitude bases had significantly higher levels of phobic-anxiety than those with lower incomes stationed at high-altitude bases. Personnel with a medium income level stationed at high-altitude bases exhibited more stable interpersonal sensitivity in comparison to those from the low-income and high-income groups stationed at high-altitude bases. Personnel in the high-income group stationed at high-altitude bases exhibited higher hostility scores.

Regarding the influence of gender, female soldiers were more prone to depression and anxiety than male soldiers.

The psychological status of personnel stationed at both high- and low-altitude bases is dynamic, influenced by factors such as income, level of education, duration of military service, and geographical setting. New recruits stationed at low-altitude bases, unmarried individuals with a lower-to-medium income level, and those with an education background of a three-year junior college diploma or below had lower levels of mental health, particularly manifesting in interpersonal sensitivity, anxiety, and phobic-anxiety symptoms. Female soldiers were more likely to experience depressive and anxiety symptoms. Married individuals stationed at high-altitude bases with a medium income level had the most stable mental health.

High-altitude units have developed effective management and emotional support models in their rotation and combat readiness of personnel stationed at high-altitude bases, setting a valuable precedent for other units to follow. However, based on further in-depth analysis of individual analyses, socio-economic analyses, and comparisons with existing studies. We found that the interaction between income, education level, and mental health can be more complex and influenced by a variety of socioeconomic and environmental factors. For example, while a high level of education relieves stress under normal circumstances, a higher level of education favors a soldier's position advancement, which will bring more responsibilities and work stress. Housing and health care are considered by all to be the two most expensive events. But due to the different rates of inflation at high and low altitudes. Soldiers at high altitudes are less stressed than those at lower altitudes.

Appropriate increases in income and welfare benefits, coupled with efforts to enhance the educational literacy of individuals with a lower education level, expand education and training in areas related to mental health, and provide targeted physiological and psychological support for female soldiers, can significantly alleviate psychological stress. To maintain a mentally healthy and stable force, we recommend implementing regular mental health assessments, provide more professional environmental adaptation psychological training and health education lectures; Establish cross-post collaboration groups to enforce the separation of educational levels in the workplace; Provide targeted one-on-one psychological counseling and sleep-emotion linkage intervention for people with psychological distress. These initiatives can enhance mental health awareness, self-monitoring, and coping skills among personnel, thereby fostering a more resilient and psychologically stable military force.

Abbreviations

SCL-90, Symptom Checklist-90; PCA, Principal component analysis; COVID-19, coronavirus disease 2019; SHAP, SHapley Additive exPlanations.

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

This study was conducted with approval from the Ethics Committee of Jinling Hospital, Affiliated Hospital of Medical School, Nanjing University (No. 2024DZKY-122-01). This study was conducted in accordance with the declaration of Helsinki. Written informed consent was obtained from all participants.

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Disclosure

The authors declare that they have no competing interests.

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