

Anxiety and Depression in Clinically Cured Leprosy patients: A Cross-sectional Survey from Hanzhong Leprosy Hospital, China

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Abstract

Background

Leprosy is a chronic mycobacterial disease that often causes permanent physical impairment and severe psychosocial burden.

Methods

This cross-sectional study recruited 115 hospitalized clinical cured leprosy patients from Hanzhong Leprosy Hospital. GAD-7, and PHQ-9 scales were adopted to evaluate anxiety and depression. Demographic and clinical data were extracted from the national leprosy management system (LEPMIS). SPSS 26.0 was used for descriptive statistics, t-test, one-way ANOVA, stepwise linear regression, Multivariate ANOVA, canonical correlation analysis (CCA) and reliability tests.

Results

Participants had a mean age of 70.70 ± 11.21 years, with 73.04% males. The positive rates of anxiety and depression were 26.09% and 24.35% by two scales. T-test and ANOVA showed higher scores in patients with advanced age, widowhood/divorce, disease duration, disability deterioration, and DDS monotherapy (all $P < 0.05$). Independent risk factors including disability deterioration, ulcers, and disease duration for GAD-7, and age, marriage, ulcer for PHQ-9 ($P < 0.05$). CCA/RDA proved significant correlations between demographic/clinical features and overall mental status ($P = 0.005$). Two scales possessed good internal consistency (Cronbach's $\alpha = 0.909$ for GAD-7, and 0.734 for PHQ-9), with positive inter-scale correlations ($r = 0.355$, $P < 0.01$).

Conclusion

Clinically cured leprosy patients carry prominent anxiety and depression burdens. Targeted mental screening and psychosocial support should be integrated into long-term leprosy management.

1. Introduction

Leprosy (also named as Hansen's disease) is a chronic infectious disease caused by *Mycobacterium leprae* that primarily affects the skin and peripheral nerves, often leading to physical disabilities, disfigurement, and severe social stigma. Despite the widespread implementation of effective multidrug therapy (MDT) recommended by the World Health Organization (WHO), leprosy remains a persistent public health challenge, with more than 172,717 new cases reported globally in 2024 [1]. Even after clinical cure, many patients continue to suffer from long-term psychosocial complications, among which anxiety and depression represent the most prevalent mental health disorders.

Anxiety and depression disorders are prevalent among patients with chronic illnesses, including leprosy, a neglected tropical disease with significant psychosocial implications. The GAD-7 is a 7-item self-report questionnaire that measures the frequency of generalized anxiety symptoms over the past two weeks, with scores ranging from 0 to 21 [2]. The PHQ-9 is a widely used self-reported depression screening tool developed by Kroenke et al. in 2001 [3]. Its brevity and efficiency make it one of the most commonly employed depression assessment scales in both clinical and research settings.

Previous studies have documented a high prevalence of anxiety and depression in leprosy patients, linked to demographic characteristics, disease severity, physical disability, social stigma, and treatment-related factors [4,5,6,7,8,9,10,11]. According to the previous studies, the prevalence of anxiety ranged from 7.14% to 62.2% for leprosy cases, while the prevalence of depression ranged from 17% to 80.0% [4,6,7,8,9,11]. For leprosy cases, the predictors were reported as age for anxiety in Democratic Republic of the Congo population [6], and female for depression in India population [4,6]. Low education was reported as the predictor for anxiety in the India leprosy cases [4], and no former education for depression in Nigeria leprosy cases [5], while higher education was associated with increased psychiatric comorbidity, involved anxiety and depression in another leprosy population in India [11]. Disability, involved hand deformity, were reported as the predictor for anxiety and depression in different population [4,6,11]. Low income was associated with anxiety [4], and unemployment and poor social support were associated with depression [5]. Both sigma and Quality of life (QoL) were associated with depression [6,9]. In addition, with regard to anxiety, males were more susceptible to the influence of disability, whereas females were more likely to be affected by environmental QoL [6].

There were seldom investigations focus on the prevalence of mental disorder of Chinese leprosy population, especially clinically cured leprosy patients. Furthermore, the risk factors for anxiety and depression among clinically cured leprosy patients remain poorly understood. Accordingly, this cross-sectional study used the GAD-7, and PHQ-9 scales to evaluate anxiety and depression among clinically cured leprosy patients at Hanzhong Leprosy hospital, Shaanxi province, China. We aimed to determine the prevalence of these mental disorders and identify their associated factors, thereby providing evidence to optimize mental health services within comprehensive leprosy care.

2. Methods

2.1 Ethical Considerations

This study was approved by the Medical Ethics Committee of Hanzhong Hospital, Hanzhong University (Approval Number: Hanzhong; Approval Date: 29/10/2024). Written informed consent was obtained from all participants. All procedures were performed in accordance with the Declaration of Helsinki.

2.2 Study Design and Setting

A cross-sectional study was conducted at Hanzhong Leprosy Hospital, Shaanxi Province, between November 1st, 2024, and June 30th, 2025. This institution is a specialized center providing comprehensive treatment, rehabilitation, and long-term care for leprosy patients.

2.3 Participants

Inclusion criteria involved clinically cured leprosy patients; ability to provide informed consent; capacity to complete all study assessments. Exclusion criteria involved severe cognitive impairment; acute severe medical illness; refusal to participate.

2.4 Data Collection

Structured face-to-face interviews were administered by trained researchers. Demographic data included gender, age, educational level, and marital status. Clinical data were extracted from the Leprosy Management Information System (LEPMIS), including age at diagnosis, diagnostic interval (time period from disease onset to diagnosis), disease duration (time period from diagnosis to last time follow up), leprosy reaction, grade of disability, EHF score at the last time follow up, neurotrophic ulcer, disability deterioration (increased grade of disability from newly diagnosis to last time follow up), relapsed, Ridley-Jopling classification, WHO classification [multibacillary (MB); paucibacillary (PB)], and treatment regimen [Dapsone single dose treatment (DDS)/Multidrug Therapy (MDT)].

2.5 Assessment Tools

GAD-7: A 7-item self-report scale measuring anxiety; total score 0–21; a score ≥ 10 indicated the presence of anxiety. PHQ-9: A 9-item self-report scale assessing depression; total score 0–27; a score ≥ 10 indicated the presence of depression.

2.6 Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics 26.0. Continuous variables were presented as mean ± standard deviation (mean ± SD), median, minimum, and maximum. Categorical variables were summarized as frequencies and percentages. Between/among-group differences were analyzed using independent-samples t-test (two groups) and one-way ANOVA (three or more groups). Stepwise linear regression analysis was used to evaluate the risk factors. Multivariate ANOVA was used to adjust for confounding factors. Canonical correlation analysis (CCA) and Redundancy analysis (RDA) were applied to explore overall linear relationships between demographic/clinical factors and psychological outcomes. The internal consistency reliability of the scales was evaluated using Cronbach’s α (≥ 0.7 deemed satisfactory). Correlation was analyzed by Pearson correlation. A two-sided P value < 0.05 was considered statistically significant.

Missing data handling

No missing values existed for core demographic, clinical, GAD-7 and PHQ-9 variables in the final analytical dataset of 115 participants. All enrolled patients fully completed structured interviews and scale assessments; incomplete questionnaires were excluded prior to formal analysis during participant screening. Therefore, no multiple imputation, listwise deletion or other missing data remedies were required in subsequent statistical models.

Sensitivity analysis design

Two sensitivity analyses were pre-specified to test the robustness of multivariate regression results:

Re-run stepwise linear regression after removing patients with disease recurrence (n = 20) to eliminate the potential interference of relapse status on mental symptoms;

Reconstruct regression models by regrouping age into two strata (< 70 years vs ≥ 70 years) instead of four subgroups, to verify whether age remained an independent predictor of depressive symptoms.

2.7 Sample Size Calculation

Sample size calculation was performed based on the previously reported prevalence of anxiety among Chinese leprosy survivors of 24.08% from a national cross-sectional study [12]. We set the two-sided significance level α = 0.05, statistical power (1 – β) = 0.80, and acceptable absolute margin of error d = 0.08. The single proportion sample size formula was adopted:

$$n = \frac{Z_{1-\alpha/2}^2 P(1-P)}{d^2}$$

Where Z0.975 = 1.96, P = 0.2408, d = 0.08. The calculated theoretical minimum sample size was 112 participants. Considering a potential 5% loss to incomplete questionnaires or invalid data, the target recruitment sample size was adjusted to 118 participants. During the study period from November 1, 2024 to June 30, 2025, a total of 115 eligible hospitalized clinically cured leprosy patients who met all inclusion criteria and provided written informed consent were consecutively enrolled. The final sample size of 115 was close to the calculated target sample and satisfied the statistical requirement for estimating the prevalence of anxiety and depression and conducting multivariate regression analysis.

3. Results

3.1 Baseline Characteristics

A total of 151 leprosy inpatients were hospitalized in Hanzhong Leprosy Hospital during the research period. Among them, 16 patients were excluded due to severe cognitive impairment and inability to finish scale assessments. Of the remaining 135 eligible patients, 20 declined to participate in the survey. Ultimately, 115 patients who met all inclusion criteria, provided written informed consent and completed all research assessments were included in the final analysis.

The mean age was 70.70 ± 11.21 years (range 33–94 years), and 73.04% (84/115) were male. The mean age at diagnosis was 30.24 ± 14.53 years; median diagnostic interval was 31.0 months; mean disease duration was 43.86 ± 17.49 years. Illiteracy was present in 65.22% (75/115) of participants, and 26.96% (31/115) were widowed or divorced. Leprosy reaction occurred in 9.57% (11/115). Grade 2 disability was observed in 83.48% (96/115), multibacillary (MB) type in 87.83% (101/115), DDS monotherapy in 54.78% (63/115), recurrence in 17.39% (20/115), disability deterioration in 62.61% (72/115), and neurotrophic ulcers in 8.70% (10/115) (Table 1).

Table 1
Demographic and clinical characteristics of participants.

Characteristic	Category	n	%
	Total	115	100.00%
Gender	Male	84	73.04%
	Female	31	26.96%
Age (years)	Min-Max	33–94	–
	mean $\pm$ SD	70.70 $\pm$ 11.21	–
	Median	72	–
Age at Diagnosis (years)	Min-Max	8–76	–
	mean $\pm$ SD	30.24 $\pm$ 14.53	–
	Median	28	–
	< 15	17	14.78%
	15–29	44	38.26%
	30–49	40	34.78%
	$\geq$ 50	14	12.17%
Diagnosis Interval (month)	Min-Max	1-210 month	–
	mean $\pm$ SD	45.70 $\pm$ 43.28	–
	Median	31	–
Diagnosis Interval (year)	< 2y	45	39.13%
	2-4.9y	40	34.78%
	5-9.9y	22	19.13%
	10y-20y	8	6.96%
Disease Duration (years)	Min-Max	6–73	–
	mean $\pm$ SD	43.86 $\pm$ 17.49	–
	Median	45	–
	$\leq$ 19y	9	7.83%
	20-39y	40	34.78%
	40-59y	39	33.91%
	$\geq$ 60y	27	23.48%
Education	Illiterate	75	65.22%
	Educated	40	34.78%
Marital Status	Unmarried	47	40.87%
	Married	37	32.17%
	Widowed/divorced	31	26.96%
Leprosy Reaction	No	104	90.43%
	Yes	11	9.57%
EHF	Min-Max	0–12	–
	mean $\pm$ SD	6.81 $\pm$ 3.88	–
	Median	7	–
Disability grade	0/1	19	16.52%
	2	96	83.48%
Ridley-Jopling classification	LL	84	73.04%
	BL	12	10.44%

	BB	4	3.48%
	BT	3	2.61%
	TT	12	10.44%
WHO Classification	PB	14	12.17%
	MB	101	87.83%
Treatment	DDS	63	54.78%
	MDT-MB	52	45.22%
Relapsed	No	95	82.61%
	Yes	20	17.39%
Disability Deterioration	No	43	37.39%
	Yes	72	62.61%
Neurotrophic Ulcer	No	105	91.30%
	Yes	10	8.70%

No missing data for any demographic or clinical variable among the 115 included participants; all study indicators were fully collected via face-to-face interview and LEPMIS database extraction.

3.2 Prevalence of Anxiety and Depression

For anxiety and depression, the mean of scores were 3.38 ± 3.57 for GAD-7, and 3.24 ± 2.19 for PHQ-9, respectively. And the prevalence of anxiety and depression were 26.09% and, 24.35% for GAD-7 and, PHQ-9, respectively (Table 2).

Table 2
Descriptive statistics of anxiety and depression scales.

Scale	Mean $\pm$ SD	Median	Min	Max	Prevalence n (%)
GAD-7	3.38 ± 3.57	3	0	19	30 (26.09%)
PHQ-9	3.24 ± 2.19	3	0	11	28 (24.35%)

3.3 Influencing factors of Anxiety and Depression

Univariate analyses using independent-samples t-test and one-way ANOVA demonstrated significant associations between demographic/clinical factors and psychological distress, with detailed significant findings as follows:

For demographic variables, older age was associated with elevated scores of two scales ($P = 0.029$, and 0.002 , for GAD-7 and, PHQ-9, respectively). Widowhood/divorce was associated with higher PHQ-9 scores ($P = 0.003$). For clinical variables, longer disease duration was associated with higher GAD-7 ($P = 0.015$). Disability deterioration was associated with higher GAD-7 ($P = 0.000$). When compared with MDT, DDS monotherapy was associated with higher GAD-7 ($P = 0.011$) (Table 3).

Table 3
Significant difference for Anxiety and Depression Scores by Different Demographic and Clinical Variables.

Grouping Variable	Subgroups (n)	GAD-7 (Mean $\pm$ SD)	PHQ-9
Gender	Female (31)	4.03 $\pm$ 3.94	3.42 $\pm$ 1.80
	Male (84)	3.14 $\pm$ 3.41	3.18 $\pm$ 2.32
	t test	1.189/	0.522
	P value	0.237	0.603
Age Group	Group 1 ($\leq$ 59y) (n = 20)	1.65 $\pm$ 2.13	2.00 $\pm$ 1.56
	Group 2 (60-69y) (n = 26)	3.00 $\pm$ 4.20	2.73 $\pm$ 2.16
	Group 3 (70-79y) (n = 41)	3.59 $\pm$ 3.63	3.49 $\pm$ 2.09
	Group 4 ($\geq$ 80y) (n = 28)	4.68 $\pm$ 3.23	4.25 $\pm$ 2.27
	F Value	3.116	5.323
	P Value	0.029*	0.002**
Marital Status	Unmarried (n = 47)	3.04 $\pm$ 3.22	3.02 $\pm$ 1.95
	Married (n = 37)	3.32 $\pm$ 3.76	2.62 $\pm$ 1.88
	Widowed/Divorced (n = 31)	3.97 $\pm$ 3.85	4.32 $\pm$ 2.52
	F Value	0.632	5.996
	P Value	0.533	0.003*
Education	Illiterate (75)	3.61 $\pm$ 3.43	3.43 $\pm$ 2.16
	Educated (40)	2.95 $\pm$ 3.81	2.90 $\pm$ 2.22
	t test	0.95	1.233
	P value	0.344	0.22
Age at Diagnosis	< 15 years (n = 17)	4.59 $\pm$ 3.55	3.71 $\pm$ 2.95
	15–29 years (n = 44)	3.64 $\pm$ 3.89	3.32 $\pm$ 2.25
	30–49 years (n = 40)	2.43 $\pm$ 2.73	2.93 $\pm$ 1.70
	$\geq$ 50 years (n = 14)	3.86 $\pm$ 4.29	3.36 $\pm$ 2.27
	F Value	1.804	0.559
	P Value	0.151	0.643
Diagnostic Interval	< 2 years (n = 45)	3.80 $\pm$ 3.84	3.42 $\pm$ 2.51
	2–5 years (n = 40)	3.25 $\pm$ 3.28	3.50 $\pm$ 2.00
	5–10 years (n = 22)	3.41 $\pm$ 3.81	2.82 $\pm$ 1.84
	10–20 years (n = 8)	1.63 $\pm$ 2.45	2.13 $\pm$ 1.81
	F Value	0.869	1.267
	P Value	0.459	0.289
Leprosy Reaction	No reaction (104)	3.55 $\pm$ 3.64	3.37 $\pm$ 2.21
	With reaction (11)	1.82 $\pm$ 2.36	2.09 $\pm$ 1.58
	t test	1.539	1.858
	P value	0.126	0.066
Disease Duration	< 20 years (n = 9)	2.56 $\pm$ 2.24	3.00 $\pm$ 2.60
	20–39 years (n = 40)	2.13 $\pm$ 3.23	2.58 $\pm$ 1.62
	40–59 years (n = 39)	3.92 $\pm$ 3.38	3.49 $\pm$ 2.34
	$\geq$ 60 years (n = 27)	4.74 $\pm$ 4.10	3.96 $\pm$ 2.38
	F Value	3.665	2.515

	P Value	0.015*	0.062
Follow-up Disability	Grade 0/1 (19)	2.58 ± 2.89	2.79 ± 1.98
	Grade 2 (96)	3.54 ± 3.62	3.35 ± 2.20
	t test	-1.076	-1.34
	P value	0.284	0.183
Disability Deterioration	No deterioration (43)	2.87 ± 3.21	2.91 ± 2.05
	Deterioration (72)	3.72 ± 3.71	3.45 ± 2.26
	t test	-4.052	-0.745
	P value	0.000**	0.458
Neurotrophic Ulcer	Without(105)	3.05 ± 3.03	3.19 ± 2.09
	With(10)	6.90 ± 6.30	3.80 ± 3.12
	t test	1.914	-0.605
	P value	0.087	0.559
Relapsed	No relapsed (95)	3.15 ± 3.48	3.12 ± 2.17
	Relapsed (20)	4.25 ± 3.76	3.85 ± 2.28
	t test	-1.06	-0.801
	P value	0.292	0.425
WHO Classification	PB (14)	2.79 ± 3.15	2.86 ± 1.97
	MB (101)	3.47 ± 3.61	3.29 ± 2.21
	t test	-0.507	1.387
	P value	0.613	0.168
Treatment	DDS (63)	3.52 ± 3.56	3.31 ± 2.18
	MDT-MB (52)	3.21 ± 3.58	3.15 ± 2.20
	t test	2.579	1.787
	P value	0.011**	0.077

*Abbreviations: GAD-7, Generalized Anxiety Disorder 7-item scale; PHQ-9, Patient Health Questionnaire 9-item scale.

*Note: *P < 0.05, *P < 0.01. Statistical significance was determined by Independent-Samples t-test (t-test) and One-way ANOVA (F value).

3.4 Risk Factor of Anxiety and Depression

Stepwise linear regression analysis revealed risk factors for psychological distress outcomes. The risk factors for GAD-7 were deterioration of disability, neurotrophic ulcer, and disease duration (P = 0.002, 0.000, and 0.011, respectively). The risk factors for PHQ-9 were age (P = 0.000). (Table 4).

Table 4
Stepwise linear regression analysis results of for GAD-7 and PHQ-9 scores.

Scales		Unstandardised Beta	95% CI	SE	Standardised Beta	t	p value	VIF	R ²	Adjusted R ²	F	P
GAD-7	Constant	-0.204	-1.864 1.456	0.838	-	-0.244	0.808	-	0.243	0.222	F(3,111) = 11.874,	P < 0.001
	Deterioration of Disability	2.007	0.777 3.237	0.621	0.274	3.233	0.002*	1.050				
	Neurotrophic Ulcer	4.100	2.033 6.167	1.043	0.325	3.931	0.000*	1.005				
	Disease Duration(y)	0.045	0.011 0.079	0.017	0.221	2.603	0.011*	1.054				
PHQ-9	Constant	-1.370	-3.822 1.081	1.237	-	-1.108	0.270	-	0.112	0.104	F(1,113) = 14.251,	P < 0.001
	Age	0.065	0.031 0.100	0.017	0.335	3.775	0.000*	1.000				

GAD-7, Generalized Anxiety Disorder-7; PHQ-9, Patient Health Questionnaire-9; CI:confidence interval; SE:Standard Error; VIF:variance inflation factor; *P < 0.05.

After adjusting for confounding factors (including gender, disease classification, and treatment history), MANOVA revealed independent factors associated with psychological distress outcomes. For two psychological scales, the overall explanatory power of the models, as indicated by R^2 values, was 0.372 for GAD-7, and 0.340 for PHQ-9 (Table 5). Specifically, marital status was significantly associated with higher PHQ-9 scores ($P < 0.001$). Disease deterioration was independently linked to elevated GAD-7 ($P = 0.001$). The presence of neurotrophic ulcer was significantly associated with higher scores on GAD-7 ($P = 0.001$), and PHQ-9 ($P = 0.047$) (Table 5.).

Table 5
MANOVA Comprehensive Results for GAD-7 and PHQ-9 Scores.

Source of Variation	DF	GAD-7 (MS/F/P)	PHQ-9 (MS/F/P)
Intercept	1	151.919/14.516/ 0.000**	42.300/10.232/ 0.002**
Gender	1	19.050/1.820/0.181 (NS)	0.071/0.017/0.896 (NS)
Age (ordinal)	3	8.848/0.845/0.473 (NS)	7.681/1.858/0.143 (NS)
Age at diagnosis (ordinal)	3	15.064/1.439/0.237 (NS)	3.305/0.799/0.498 (NS)
Education (Culture)	1	28.990/2.770/0.100 (NS)	5.753/1.392/0.241 (NS)
Marital status (Marriage)	2	3.694/0.353/0.704 (NS)	29.243/7.074/ 0.001**
Diagnostic interval (ordinal)	3	8.067/0.771/0.513 (NS)	6.950/1.681/0.177 (NS)
Disease duration (Onset interval)	3	7.627/0.729/0.538 (NS)	0.289/0.070/0.976 (NS)
Leprosy reaction	1	0.694/0.066/0.797 (NS)	3.539/0.856/0.357 (NS)
Follow-up disability (2/non-2)	1	10.455/0.999/0.320 (NS)	5.834/1.411/0.238 (NS)
Deterioration	1	115.220/11.010/ 0.001**	0.084/0.020/0.887 (NS)
Recurrence	1	0.888/0.085/0.771 (NS)	3.514/0.850/0.359 (NS)
RJ classification (RJ)	4	0.311/0.030/0.998 (NS)	4.287/1.037/0.393 (NS)
WHO classification (WHO)	1	0.292/0.028/0.868 (NS)	3.869/0.936/0.336 (NS)
Treatment	1	0.022/0.002/0.963 (NS)	2.357/0.570/0.452 (NS)
Ulcer	1	118.405/11.314/ 0.001**	16.781/4.059/ 0.047*
Residual	87	10.465/-/-	4.134/-/-
R2		0.372	0.34

MANOVA, Multivariate Analysis of Variance; DF, degrees of freedom; MS, mean square; F, F value; P, P value; GAD-7, Generalized Anxiety Disorder-7; PHQ-9, Patient Health Questionnaire-9; NS, not significant ($P \geq 0.05$); * $P < 0.05$, ** $P < 0.01$.

3.5 CCA and RDA for Psychological Distress

Two CCA models were constructed: Model 1 (demographic indicators) and Model 2 (clinical indicators), with Wilks' λ tests to evaluate canonical variate significance. Two canonical functions were identified, however, only the first canonical variate pair reached significance in both models: Model 1 ($r = 0.443$, Wilks' $\lambda = 0.785$, $F = 1.944$, $P = 0.024$) and Model 2 ($r = 0.405$, Wilks' $\lambda = 0.820$, $F = 2.834$, $P = 0.005$). All subsequent canonical variate pairs were non-significant (all $P > 0.05$) (Table 6).

Table 6
Canonical Correlation Coefficients and Significance Tests

Model	Canonical Variate Pair	Canonical Correlation Coefficient	Wilks' λ	df 1	df 2	F Value	P Value
Model 1	1	0.443	0.785	14	212	1.944	0.024*
Demographic Indicators	2	0.153	0.977	6	107	0.425	0.861
Model 2	1	0.405	0.82	8	218	2.834	0.005**
Clinical Indicators	2	0.137	0.981	3	110	0.701	0.553

Wilks' λ , Wilks' lambda; df, degrees of freedom; * $P < 0.05$, ** $P < 0.01$.

Table 7 shows the standardized canonical coefficients of the first canonical variates (U1 for demographic indicators and V1 for psychological scores).

Standardized canonical correlation model between demographic indicators and psychological indicators were as follows: $U1 = 0.025X1 - 0.008X2 - 0.035X3 - 0.037X4$; $V1 = -0.011Y1 - 0.033Y2$.

Table 7
Coefficients of standardized canonical variables for demographic indicators and psychological scores of leprosy cases.

Demographic Indicators		Psychological Scores	
Variables	U1	Variables	V1
Gender (X1)	0.025	GAD-7(Y1)	-0.011
Age (X2)	-0.008	PHQ-9(Y2)	-0.033
Education level (X3)	-0.035		
Marital status (X4)	-0.037		
X variables: Demographic indicators;			

Y variables, psychological assessment scores; GAD-7, Generalized Anxiety Disorder 7-item scale; PHQ-9, Patient Health Questionnaire 9-item scale.

Table 8 presents the standardized canonical coefficients of the first canonical variates (U1 for clinical indicators and V1 for psychological scores) for leprosy cases.

Standardized canonical correlation model between clinical indicators and psychological indicators were as follows: $U1 = -0.003X1 - 0.000X2 - 0.05X3 + 0.019X4 + 0.072X5 - 0.098X6 - 0.002X7 + 0.007X8 + 0.038X9 - 0.167X10 - 0.011X11 - 0.195X12$, $V1 = -0.024Y1 - 0.007Y2$.

Table 8
Coefficients of standardized canonical variables for clinical indicators and psychological scores of leprosy cases.

Clinical Indicators		Psychological Scores	
Variables	U1	Variables	V1
Age at diagnosis (X1)	-0.003	GAD-7 (Y1)	-0.024
Diagnostic interval (X2)	0	PHQ-9 (Y2)	-0.007
Onset interval (X3)	-0.005		
Leprosy reaction (X4)	0.019		
Follow-up disability (X5)	0.072		
Deterioration (X6)	-0.098		
Follow-up EHF (X7)	-0.002		
Recurrence (X8)	0.007		
RJ classification (X9)	0.038		
WHO classification (X10)	-0.167		
Treatment (X11)	-0.011		
Ulcer (X12)	-0.195		
X variables: Clinical Indicator;			

Y variables, psychological assessment scores; GAD-7, Generalized Anxiety Disorder 7-item scale; PHQ-9, Patient Health Questionnaire 9-item scale.

Redundancy analysis (RDA) was conducted with anxiety and depression indicators as response variables and demographic and disease course factors as explanatory variables. The overall model was highly significant ($F = 1.583$, $P = 0.000$). Demographic and clinical factors explained 15.78% of the total variance in psychological indicators, among which the first ordination axis (RDA1) was the main contributing dimension, explaining 11.14% of the total variance. Key influencing factor involved age, disability deterioration, ulceration, and disease duration were correlated with anxiety and depression levels (Table 9).

Table 9
Summary of redundancy analysis (RDA) results.

Group	F value	P value	Total explained variance	RDA1 explained variance	Key influencing factors
GAD-7 + PHQ-9	1.583	0.000**	15.78%	11.14%	Age, Deterioration, Ulcer, Disease duration

3.6 The Internal Consistency and Correlation

The internal consistency of GAD-7, HAM-A, PHQ-9, and HAM-D was evaluated using item-total correlation coefficient (CITC) and Cronbach's alpha (α). GAD-7 had an overall Cronbach's alpha of 0.909 with CITC values of its 7 items ranging from 0.650 to 0.770, and Cronbach's alpha values when each item was eliminated ranging from 0.892 to 0.903, indicating excellent internal consistency. PHQ-9 had an overall Cronbach's alpha of 0.734, with CITC values of its 9

items ranging from 0.251 to 0.540 and Cronbach's alpha values when each item was eliminated ranging from 0.684 to 0.738, indicating acceptable internal consistency (Table 10.).

Table 10			
The internal consistency of GAD-7 and PHQ-9.			
Items	CITC	Cronbach's alpha (α) if the Item is Eliminated	Cronbach's alpha (α)
The internal consistency of GAD-7			
Q1	0.703	0.899	0.909
Q2	0.77	0.892	
Q3	0.758	0.892	
Q4	0.745	0.894	
Q5	0.65	0.903	
Q6	0.729	0.895	
Q7	0.743	0.894	
The internal consistency of PHQ-9			
Q1	0.537	0.685	0.734
Q2	0.518	0.69	
Q3	0.293	0.729	
Q4	0.357	0.721	
Q5	0.335	0.722	
Q6	0.465	0.709	
Q7	0.54	0.684	
Q8	0.478	0.698	
Q9	0.251	0.738	

In addition, positive correlations were found for GAD-7 with PHQ-9 (r = 0.355, P < 0.01).

3.7 Sensitivity Analysis

After excluding 20 patients with disease recurrence, stepwise linear regression was repeated for GAD-7 and PHQ-9 scores. For GAD-7, disability deterioration, neurotrophic ulcer and longer disease duration still remained significant independent risk factors (all P < 0.05). For PHQ-9, advanced age retained statistical significance as an independent predictor (P < 0.001). No substantial changes were observed in model R² and regression coefficient magnitudes, indicating stable results after removing relapsed patients (Table 11).

Table 11												
Stepwise linear regression analysis results of for GAD-7 and PHQ-9 scores after excluding recurrent patients.												
Scales		Unstandardised Beta	95% CI	SE	Standardised Beta	t	p value	VIF	R ²	Adjusted R ²	F	P
GAD-7	Constant	-0.143	-1.929 1.643	0.899	-	-0.159	0.874	-	0.223	0.197	F (3,91) = 8.709,	p = 0.001
	Deterioration of Disability	1.934	0.595 3.272	0.674	0.269	2.87	0.005**	1.03				
	Neurotrophic Ulcer	3.615	1.398 5.832	1.116	0.3	3.239	0.002**	1.002				
	Disease Duration(y)	0.046	0.007 0.086	1.116	0.3	3.239	0.002**	1.002				
PHQ-9	Constant	-1.013	-3.445 1.418	1.224	-	-0.828	0.41	-	0.115	0.105	F(1,91) = 11.818	P = 0.001
	Age	0.06	0.025 0.095	0.017	0.339	3.438	0.001**	1				

GAD-7, Generalized Anxiety Disorder-7; PHQ-9, Patient Health Questionnaire-9; CI:confidence interval; SE:Standard Error; VIF:variance inflation factor; *P < 0.05.

4. Discussion

This cross-sectional study investigated anxiety and depression in 115 clinically cured leprosy patients at Hanzhong Leprosy hospital, identifying their prevalence, associated factors, and validating the psychometric properties of four psychiatric scales. The findings confirm a notable mental health burden in

this population, clarify key risk factors for psychological distress, and provide evidence for optimizing integrated mental health care in long-term leprosy management.

4.1 Prevalence Discrepancies Between Assessment Modalities

Anxiety and depression prevalence were a consistent 26.09% and 24.35% across the self-reported GAD-7 and PHQ-9, falling within the range of international studies [4,6,7,11] and aligning with a nationwide Chinese study for leprosy patients, in which 24.08% leprosy patients reported anxiety by SAS and 22.51% leprosy patients reported depression by SDS scales [12], confirming anxiety and depression as common mental health issues in Chinese clinical cured leprosy patients.

4.2 Key Demographic and Clinical Risk Factors

In this study, advanced age, widowhood/divorce, disease duration, disability deterioration, and ulcer were identified as key factors associated with elevated anxiety/depression scores, with dynamic clinical events exerting a stronger impact than static baseline characteristics. The result was consistent with previous studies. In the meta-analysis, both demographics, such as age, gender, marital status, occupation, environment, and religion, and disease-related factors, involved visible impairments, duration of disease, and treatment, were associated with mental wellbeing of leprosy-affected persons and their family members [13].

It was reported that, common mental disorders were associated with female, age, low family income, and unsatisfactory quality of life in the physical domain and the psychological domain for leprosy patients [14]. In addition, increasing age, male gender and disability were significantly associated with multimorbidity, such as diabetes and depression, for leprosy population [15]. Age was also reported as the risk factor of psychological health for people affected by leprosy in the community of Guangdong China [16], and also in this study. Advanced age was related to the psychological scale, may attributable to cumulative physical disability, age-related functional decline, and social disconnection.

Widowhood/divorce was related to higher PHQ-9 scores, reflecting the critical role of spousal and family support in mitigating psychological distress. Evidence indicates that divorce and widowhood substantially elevate the risks of psychological distress, emotional disorders, anxiety and depression, with widowhood particularly exacerbating depressive symptoms in older adults[17][18]. In low-income sociocultural settings, marital dissolution (i.e., divorce, widowhood, and separation) is positively associated with depressive symptoms among middle-aged and elderly individuals [19]. Additionally, families affected by leprosy show higher psychiatric morbidity [20], while social capital including social support and favorable neighborhood relations effectively buffers the detrimental mental health effects of widowhood [21].

Disease duration has been reported as a factor associated with depression among leprosy patients from Fujian, Yunnan, Shandong, and Guizhou provinces of China. [12]. Consistently, our cross-sectional study observed an association between longer disease duration and higher anxiety scores among clinically cured leprosy patients in Shaanxi, China. Time is a critical factor contributing to the deterioration of leprosy-related disability. Patients' risk of worsening disability grade increased with age, was greater for patients with a long duration of symptom, was higher for defaulter patients, and was lower for patients who did not lose their sensibility throughout therapy [22].

Progressive disability is suggested to contribute to persistent physical discomfort, amplified social stigma, and reduced self-efficacy, forming a potential vicious cycle between physical impairment and negative emotions. [4,6,11]. More severe disabilities of leprosy were associated with more severe outcomes for mental wellbeing, participation restriction and stigma [23]. The previous study also suggest that stigma and leprosy-related disability are associated with deteriorated quality of life among leprosy patients, with stigma serving as the predominant contributor to such deterioration [24].

DDS monotherapy correlated with higher GAD-7 scores in univariate analysis ($P < 0.05$), may due to longer disease duration and limited multidisciplinary care compared to MDT-MB. Notably, static baseline characteristics (e.g., leprosy reaction, disability grade, WHO classification) were not independent predictors after confounding adjustment, indicating that dynamic disease course changes have a more profound mental health impact than fixed baseline features—a novel finding supplementing previous research focused on baseline disability.

4.3 CCA/RDA of Demographic/Clinical Indicators and Psychological Distress

Canonical correlation analysis (CCA) is widely adopted to explore the holistic linear association between a set of independent demographic and clinical predictors and a battery of anxiety and depression outcome scales across various populations, including patients with chronic somatic and neurological disorders, psychiatric outpatients, and student cohorts [25,26,27]. Unlike simple correlation or regression that only evaluates single-variable relationships, CCA can simultaneously model the combined effect of multiple clinical indicators on the full spectrum of emotional symptoms measured by multi-modal psychiatric scales [28]. Prior CCA-based studies among chronic disease patients, such as Parkinson's disease, COPD and HIV-infected individuals, consistently identified significant canonical pairs linking physical disease manifestations to overall anxiety-depressive distress [26,27,29]. CCA also serves as a reliable method for scale development and item screening for disease-specific emotional assessment tools [30]. Consistent with existing literature, our CCA results demonstrated significant first canonical variate pairs for demographic and clinical predictors, further confirming that cumulative demographic features and dynamic disease complications jointly contribute to psychological burden among cured leprosy patients. Nevertheless, CCA only reveals correlational rather than causal relationships, which necessitates stepwise regression and longitudinal follow-up to clarify independent risk factors. In this study, RDA also confirmed significant associations between demographic/clinical indicators and psychological distress, with age, deterioration, ulcer, and disease duration significant with anxiety and depression. Collectively, CCA and RDA results further support these observed correlations between demographic-clinical characteristics and psychological distress..

4.4 Psychometric Validity of the Psychiatric Scales

Extensive psychometric studies have systematically compared the reliability and validity of anxiety and depression scales across chronic somatic, neurological and disabled populations [31,32,33]. Internal consistency and inter-scale correlation analyses validated the reliability and construct validity of the GAD-7 and PHQ-9 in the population. In this study, GAD-7 exhibited excellent internal consistency, confirming stable measurement properties for anxiety and depression. PHQ-9 also had acceptable internal consistency.

4.5 Clinical Implications

The findings of this study have important clinical implications for the long-term management of clinically cured leprosy patients in China and other endemic regions:

Implement routine mental health screening:

GAD-7 and PHQ-9 are recommended as rapid, first-line screening tools for anxiety and depression in the leprosy population, due to their simplicity and good reliability.

Targeted intervention for high-risk subgroups:

Priority mental health support should be provided to patients with advanced age, widowhood/divorce, disability deterioration, or neurotrophic ulcers—interventions may include psychological counseling, cognitive behavioral therapy (CBT), and social support programs to alleviate negative emotions and improve coping strategies [34].

Integrate physical rehabilitation and mental health care:

Given the strong association between dynamic clinical events (disability deterioration, ulcers) and psychological distress, clinical management should focus on not only preventing and treating disability progression and neurotrophic ulcers, but also mental health assessment into regular follow-up to form a holistic care model.

4.7 Limitations and Future Directions

This study has notable limitations: a single-center cross-sectional design, which focused on hospitalized clinical cured leprosy patients, limits causal inference and generalizability to community-dwelling leprosy patients; unassessed psychosocial factors (stigma, social support, socioeconomic status); and only partial psychometric validation (internal consistency, construct validity) of the scales. Future research should conduct multi-center longitudinal studies to explore causal relationships and dynamic mental health changes, incorporate psychosocial factor assessments, and fully validate the scales' criterion validity and test-retest reliability in leprosy patients. Interventional studies are also needed to evaluate the efficacy of integrated physical-mental health care models for alleviating anxiety and depression. In addition, our study only captures cross-sectional associations rather than temporal causal relationships. We cannot distinguish whether poor mental status preceded physical complications or vice-versa. Moreover, self-report screening scales (GAD-7, PHQ-9) identify symptom positivity but cannot substitute formal psychiatric clinical diagnosis. Generalizability is further limited because participants are hospitalized in-patients rather than community-dwelling cured leprosy survivors.

5. Conclusion

Hospitalized clinically cured leprosy patients face a substantial mental health burden, with moderate anxiety and depression prevalence. Advanced age, widowhood or divorce, longer disease duration, disability deterioration, and neurotrophic ulcers were key independently-associated factors for anxiety-depressive symptoms in this hospitalized cohort, with dynamic clinical events impacting mental health more than static baseline characteristics. The GAD-7, and PHQ-9 demonstrate good reliability and validity in this population, and the assessment is recommended for mental health screening. Routine mental health assessment, targeted high-risk interventions, and integrated physical-mental health care should be embedded in long-term leprosy management to alleviate psychological distress and improve patients' quality of life.

Declarations

Relevance to Clinical Practice

This research verifies that GAD-7 and PHQ-9 are reliable brief screening tools to detect anxiety and depression in clinically cured leprosy survivors. Frontline clinicians should regularly conduct mental assessments during follow-ups and deliver targeted psychological interventions for high-risk groups, including aged, widowed patients and those with deteriorating physical disability or neurotrophic ulcers, to realize integrated physical and mental rehabilitation of leprosy patients.

Availability of Data and Materials

All minimal datasets required to replicate all study findings, including raw values of means, standard deviations, source data for all figures and extracted analytical data from images, are fully available within the manuscript. Therefore, no external public repository deposition is required.

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Competing Interests

The authors declare no potential conflicts of interest in relation to this research, its writing, or publication.

Author Contributions Statement

Guo Chonglin, Mei Rong, Du Juan, and Zhao Li collected data and prepared table 1-2, Liu Yapeng, and Chen Xiaohua performed Statistical analysis, prepared Table 3-11 and Figure 1, and Chen Xiaohua wrote the main manuscript text. All authors reviewed the manuscript.

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Figures

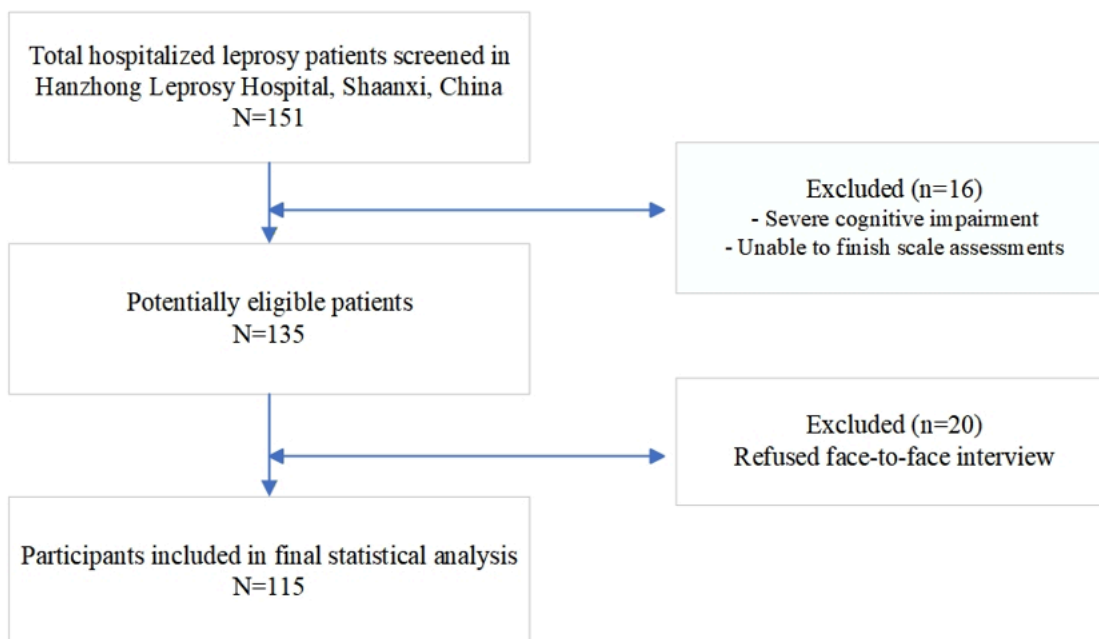


Figure 1

Flow diagram of participant selection.