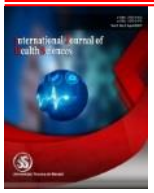

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Functional Impairment and Disability in Euthymic Libyan Adults with Bipolar Disorder: A Cross-Sectional Study

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Abstract

Background: Bipolar disorder is a primary contributor to global disability. A critical gap exists between symptomatic remission and functional recovery, with many patients experiencing persistent impairment even during euthymia. However, empirical data from North African populations, particularly Libya, remain scarce. This study aimed to quantify the extent of this issue in a Libyan clinical sample. **Objective:** To assess the prevalence and severity of functional impairment and disability in euthymic Libyan patients with BPD and to identify associated socio-demographic and clinical correlates. **Methods:** In this cross-sectional study, 100 outpatients with a DSM-5 diagnosis of BPD were recruited from three psychiatric clinics in Libya. Euthymia was confirmed using cutoff scores of ≤7 on the Hamilton Depression Rating Scale and ≤6 on the Young Mania Rating Scale. Functional impairment was evaluated using the Functioning Assessment Short Test, and disability was measured with the World Health Organization Disability Assessment Schedule. Associations were analysed using Chi-square tests, with significance set at $p < 0.05$. **Results:** The sample comprised 100 participants (97% with Bipolar I Disorder). Despite being in remission, only 44.0% exhibited normal functioning, while 35.0% had mild, 18.0% moderate, and 3.0% severe functional impairment. Similarly, only 35.0% were without disability; 52.0% experienced mild, 10.0% moderate, and 3.0% severe disability. A highly significant positive correlation was found between functional impairment and disability ($\chi^2 = 123.18$, $p < 0.001$). Factors significantly associated with higher levels of both disability and impairment included older age, unemployment, longer duration of illness, a greater number of relapses, and a positive family history of psychiatric illness ($p < 0.05$ for all). **Conclusion:** Most of Libyan patients with BPD experience significant functional impairment and disability despite achieving symptomatic remission. These findings underscore the need for clinical management to extend beyond mood stabilization to include targeted psychosocial and vocational rehabilitation to improve real-world outcomes and promote genuine recovery.

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Contents

1 Introduction

Bipolar disorder (BPD) is a severe, chronic psychiatric illness characterized by recurrent episodes of mania or hypomania and depression (Weissman et al., 1996). Affecting approximately 1% of the global population, BPD represents a major public health concern. According to the World Health Organization, it is one of the top ten leading causes of disability worldwide, imposing a substantial burden on individuals, families, and healthcare systems through lost productivity and diminished quality of life (Murray & Lopez, 1997). The clinical course of BPD is highly variable, often involving psychotic features, cognitive deficits, and a high risk of suicide, which complicate its long-term management (Judd et al., 2002).

A critical distinction exists between symptomatic remission and functional recovery as the primary goal of pharmacotherapy is to achieve and maintain euthymia (a stable mood state free from significant manic or depressive symptoms) (Grande et al., 2016). Still, this clinical stability does not guarantee a return to pre-morbid levels of functioning (Judd et al., 2005). Functional impairment refers to persistent difficulties in key life domains, including occupational performance, interpersonal relationships, cognitive processing, and independent living. Evidence from longitudinal studies has demonstrated that most individuals with BPD continue to experience significant psychosocial and vocational deficits even during periods of syndromal remission (Judd et al., 2005; Chaudhury et al., 2006). This gap highlights that symptom control alone is an insufficient endpoint for determining the success of treatment.

The persistence of functional impairment in BPD is well-documented, but most of this research originates from high-income Western nations. There is a conspicuous lack of empirical data from the Middle East and North Africa (MENA) region, including Libya. Extrapolating findings across diverse populations is problematic, as sociocultural factors such as family structures, levels of social stigma, and access to healthcare and vocational support can influence functional outcomes. Therefore, understanding the specific patterns and correlates of disability in a Libyan context is essential for developing culturally relevant clinical guidelines and targeted interventions (Szmulewicz et al., 2017).

The present study was designed to address this knowledge gap by providing the first systematic assessment of functional impairment and disability among Libyan adults with BPD. The primary objective was to determine the prevalence and severity of these deficits in a sample of euthymic outpatients. Secondary objectives were to explore the associations between functional outcomes and key socio-demographic (e.g., age, occupation) and clinical (e.g., illness duration, number of relapses, family history) variables. It was hypothesized that a significant proportion of the sample would exhibit functional deficits despite clinical remission, and that poorer outcomes would be associated with a more severe course of illness (Fountoulakis et al., 2005).

2 Materials and Methods

Study Design and Setting

A cross-sectional study design was employed to assess disability and functional impairment in patients with bipolar disorder. Data were collected between 2023 and 2024 from participants recruited from three specialized outpatient psychiatric clinics in Libya: The Psychiatric Outpatient Clinic of Zliten Medical Center, Al Irada Clinic in Zliten, and Psycare Clinic in Tripoli.

Participants
The study population consisted of 100 adult outpatients with a confirmed diagnosis of Bipolar I or Bipolar II Disorder, established by their treating psychiatrist according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria.

Inclusion Criteria:
1) Confirmed DSM-5 diagnosis of Bipolar I or Bipolar II Disorder.
2) Age of 17 years or older.
3) Currently in a euthymic state, as defined by scores on standardized rating scales.
4) Ability to comprehend and respond to study questionnaires.
5) Provision of written informed consent.

Exclusion Criteria:
1) Presence of a severe, unstable comorbid medical or neurological condition that could confound the assessment of functioning.
2) A comorbid psychiatric diagnosis (e.g., schizophrenia, primary substance use disorder) that could be the primary driver of disability.
3) Inability to provide reliable self-report or absence of a dependable caregiver for collateral information when necessary.
4) Refusal to provide consent.

Procedure
Potential participants were identified by their treating psychiatrists during routine clinical appointments. Those who met the initial eligibility criteria were referred to a trained researcher who provided a detailed explanation of the study's purpose and procedures. After obtaining written informed consent, the researcher conducted a structured interview to administer the study instruments. The entire assessment was completed in a single session.

Measures
A battery of standardized instruments was used to collect data.
Socio-demographic and Clinical Data: A custom-designed questionnaire was used to gather information on age, gender, occupation, education, age at illness onset, duration of illness, and number of previous mood episodes.
Assessment of Remission Status: Euthymia was operationally defined by meeting criteria on both of the following scales:
1) *Hamilton Depression Rating Scale (HAM-D):* The 17-item version was used to measure the severity of depressive symptoms. A total score of ≤7 was required to confirm remission from depression.
2) *Young Mania Rating Scale (YMRS):* This 11-item, clinician-rated scale was used to assess manic symptoms. A total score of ≤6 was required to confirm remission from mania/hypomania.

Outcome Measures:
3) *Functioning Assessment Short Test (FAST):* This 24-item, multidimensional scale was used to assess functional impairment specifically in patients with BPD. It covers six domains: autonomy, occupational

functioning, cognitive functioning, financial issues, interpersonal relationships, and leisure time (Rosa et al., 2007).

4) *World Health Organization Disability Assessment Schedule 2.0 (WHODAS 2.0):* This standardized, 36-item instrument was used to measure general health and disability across six life domains: cognition, mobility, self-care, having a good relationship with people, life activities, and participation in society. It provides a global disability score (Rehabilitation Committee of the Indian Psychiatry Society, 2002).

Statistical Analysis

All data were coded and analysed using the IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, N.Y., USA). Descriptive statistics were used to summarize the sample's characteristics; categorical variables were presented as frequencies (n) and percentages (%), while continuous variables were presented as means and standard deviations (SD). The Chi-square (χ^2) test was used to examine the associations between categorical variables, specifically comparing levels of disability and functional impairment across different socio-demographic and clinical groups. A two-tailed p-value of < 0.05 was considered statistically significant for all analyses.

3 Results and Discussions

3.1 Results

Socio-demographic and Clinical Characteristics of the Sample

A total of 100 participants meeting the criteria for euthymic bipolar disorder were included in the analysis. The socio-demographic and clinical characteristics of the sample are detailed in **Table 1**.

Table 1
Demographic and Basic Clinical Data of the Studied Patients (N=100)

Characteristic	Subgroup	N	Percent (%)
Age Group	<25 yrs	21	21.0
	25-50 yrs	70	70.0
	> 50 yrs	9	9.0
Mean Age (SD)		37.7 (12.2)	
Sex	Male	57	57.0
	Female	43	43.0
Occupation	Hard work	11	11.0
	Housewife	10	10.0
	Light work	11	11.0
	Not working	44	44.0
	Self-work	3	3.0
	Student	21	21.0
Onset of Illness	< 5 yrs	21	21.0
	5-10 yrs	27	27.0
	10-20 yrs	31	31.0
	> 20 yrs	21	21.0
Mean Duration (SD), yrs		13.2 (8.0)	
Number of Relapses	< 3	37	37.0
	3-6	49	49.0
	> 7	14	14.0
Time Since Last Relapse	< 12 months	62	62.0

Characteristic	Subgroup	N	Percent (%)
	> 12 months	38	38.0
Family History	No	77	77.0
	Yes	23	23.0

The mean age of participants was 37.7 (SD = 12.2) years, with a slight male predominance (57.0%). A significant portion of the sample was not working (44.0%). The mean duration of illness since onset was 13.2 (SD = 8.0) years. Most participants (97.0%) were diagnosed with Bipolar I Disorder (**Table 2**). A positive family history of psychiatric illness was reported by 23.0% of the sample.

Table 2
Distribution of Bipolar Disorder Subtype (N=100)

Bipolar Subtype	Number	Percent (%)
Bipolar I	97	97.0
Bipolar II	3	3.0
Total	**100**	**100.0**

Prevalence of Functional Impairment and Disability
Despite being in symptomatic remission, a substantial proportion of the sample reported significant levels of functional impairment and disability (**Table 3**).

Table 3
Distribution of Functioning and Disability Assessment Scores (N=100)

Assessment Item	No (N, %)	Mild (N, %)	Moderate (N, %)	Severe (N, %)
Functioning Assessment	**44 (44.0%)**	**35 (35.0%)**	**18 (18.0%)**	**3 (3.0%)**
Autonomy	56 (56.0%)	27 (27.0%)	14 (14.0%)	3 (3.0%)
Occupational Functioning	34 (34.0%)	17 (17.0%)	32 (32.0%)	17 (17.0%)
Cognitive Functioning	58 (58.0%)	27 (27.0%)	9 (9.0%)	6 (6.0%)
Financial Issues	55 (55.0%)	17 (17.0%)	2 (2.0%)	26 (26.0%)
Interpersonal Relationships	49 (49.0%)	27 (27.0%)	9 (9.0%)	15 (15.0%)
Leisure Time	23 (23.0%)	6 (6.0%)	20 (20.0%)	51 (51.0%)
Disability Assessment	**35 (35.0%)**	**52 (52.0%)**	**10 (10.0%)**	**3 (3.0%)**

Regarding functional impairment, 44.0% (n=44) of participants were assessed as having normal functioning. However, 35.0% (n=35) experienced mild impairment, 18.0% (n=18) had moderate impairment, and 3.0% (n=3) had severe impairment.
Similarly, for disability, only 35.0% (n=35) of participants were free of disability. The majority (52.0%, n=52) reported mild disability, while 10.0% (n=10) reported moderate and 3.0% (n=3) reported severe disability.

Association between Functional Impairment and Disability
A strong, statistically significant association was observed between the levels of functional impairment and disability (**Table 4**). As the severity of functional impairment increased, the severity of disability also increased ($\chi^2 = 123.180$, $p < 0.001$). For instance, all three participants with severe functional impairment also had severe disability, whereas 77.1% of those with no disability had normal functioning (**Figure 1**).

Table 4
Relation Between Disability Assessment and Functioning Assessment Scores

Functioning	Disability Assessment				Total
Assessment	No (N=35)	Mild (N=52)	Moderate (N=10)	Severe (N=3)	N=100
No	27 (77.1%)	14 (26.9%)	3 (30.0%)	0 (0.0%)	44 (44.0%)
Mild	5 (14.3%)	25 (48.1%)	5 (50.0%)	0 (0.0%)	35 (35.0%)
Moderate	3 (8.6%)	13 (25.0%)	2 (20.0%)	0 (0.0%)	18 (18.0%)
Severe	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (100.0%)	3 (3.0%)
Total	**35 (100%)**	**52 (100%)**	**10 (100%)**	**3 (100%)**	**100 (100%)**
$\chi^2 = 123.180, p < 0.001$*					

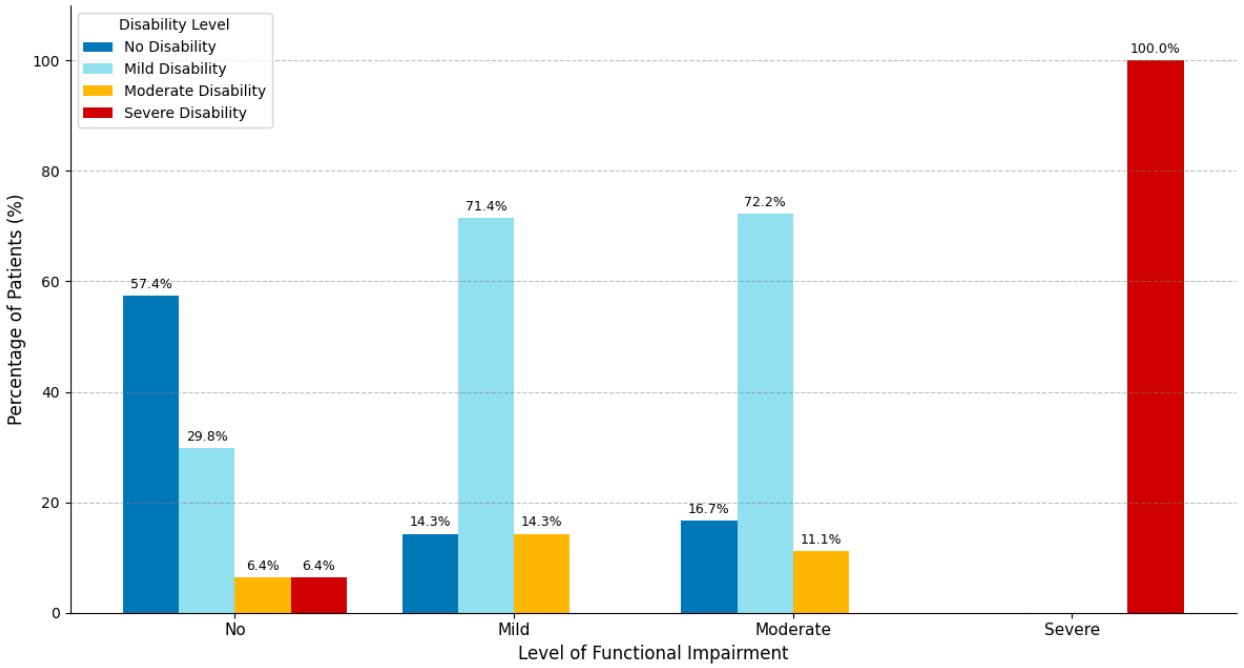

Figure 1: Distribution of Disability by Level of Functional Impairment

Correlates of Disability

Several socio-demographic and clinical factors were associated with the level of disability (**Table 5**). Higher disability levels were significantly correlated with:
Age: Older participants, particularly those over 50 years, reported higher rates of severe disability compared to younger participants ($p < 0.001$).
Occupation: Participants who were not working had significantly higher rates of moderate and severe disability compared to those who were employed or students ($p < 0.001$).
Onset and Duration of Illness: A longer duration since illness onset was associated with greater disability, with the highest rates of moderate and severe disability found in those with an illness duration exceeding 20 years ($p < 0.001$).
Number of Relapses: A higher number of relapses was significantly associated with increased disability ($p < 0.001$).
Family History: Participants with a positive family history of psychiatric illness had significantly higher rates of moderate and severe disability compared to those without ($p < 0.001$).

Table 5
Relation Between Disability Assessment and Socio-demographic/Clinical Data

Characteristic	Category	No Disability (N=35) N (%)	Mild Disability (N=52) N (%)	Moderate Disability (N=10) N (%)	Severe Disability (N=3) N (%)	χ^2	P-value
Age Group	<25 yrs	14 (40.0)	6 (11.5)	1 (10.0)	0 (0.0)	44.993	**0.001***
	25-50 yrs	21 (60.0)	40 (76.9)	9 (90.0)	0 (0.0)		
	> 50 yrs	0 (0.0)	6 (11.5)	0 (0.0)	3 (100.0)		
Sex	Male	24 (68.6)	27 (51.9)	3 (30.0)	3 (100.0)	7.696	0.074
	Female	11 (31.4)	25 (48.1)	7 (70.0)	0 (0.0)		
Occupation	Hard work	7 (20.0)	4 (7.7)	0 (0.0)	0 (0.0)	37.863	**0.001***
	Housewife	2 (5.7)	6 (11.5)	2 (20.0)	0 (0.0)		
	Light work	5 (14.3)	5 (9.6)	1 (10.0)	0 (0.0)		
	Not working	5 (14.3)	30 (57.7)	6 (60.0)	3 (100.0)		
	Self-work	0 (0.0)	3 (5.8)	0 (0.0)	0 (0.0)		
	Student	16 (45.7)	4 (7.7)	1 (10.0)	0 (0.0)		
Onset of Illness	< 5 yrs	13 (37.1)	5 (9.6)	3 (30.0)	0 (0.0)	90.881	**0.001***
	5-10 yrs	22 (62.9)	5 (9.6)	0 (0.0)	0 (0.0)		
	10-20 yrs	0 (0.0)	31 (59.6)	0 (0.0)	0 (0.0)		
	> 20 yrs	0 (0.0)	11 (21.2)	7 (70.0)	3 (100.0)		
Number of Relapses	< 3	31 (88.6)	3 (5.8)	3 (30.0)	0 (0.0)	83.508	**0.001***
	3-6	2 (5.7)	40 (76.9)	7 (70.0)	0 (0.0)		
	> 7	2 (5.7)	9 (17.3)	0 (0.0)	3 (100.0)		
Time Since Last Relapse	< 12 months	26 (74.3)	25 (48.1)	8 (80.0)	3 (100.0)	4.735	0.082
	> 12 months	9 (25.7)	27 (51.9)	2 (20.0)	0 (0.0)		
Family History	No	29 (82.9)	43 (82.7)	5 (50.0)	0 (0.0)	15.789	**0.001***
	Yes	6 (17.1)	9 (17.3)	5 (50.0)	3 (100.0)		

Note: Percentages represent column percentages. P-values < 0.05 are considered significant.

Correlates of Functional Impairment

The analysis of factors associated with functional impairment revealed similar patterns (**Table 6**). Poorer functional outcomes were significantly associated with:
Age: Participants over 50 years had the highest rates of moderate and severe functional impairment ($p < 0.001$).
Onset and Duration of Illness: A longer illness duration was strongly correlated with worse functioning ($p < 0.001$).
Number of Relapses: A greater number of relapses was associated with significantly poorer functional scores ($p < 0.001$).
Time Since Last Relapse: Participants who had a relapse within the last 12 months had significantly worse functional outcomes compared to those with a longer period of remission ($p = 0.005$).
Family History: A positive family history was associated with higher levels of moderate and severe functional impairment ($p = 0.014$).

Table 6
Relation Between Functional Assessment and Socio-demographic/Clinical Data

Characteristic	Category	No Functioning Impairment (N=44) N (%)	Mild Impairment (N=35) N (%)	Moderate Impairment (N=18) N (%)	Severe Impairment (N=3) N (%)	χ^2	P-value
Age Group	<25 yrs	14 (31.8)	5 (14.3)	2 (11.1)	0 (0.0)	48.333	**0.001***
	25-50 yrs	29 (65.9)	30 (85.7)	11 (61.1)	0 (0.0)		
	> 50 yrs	1 (2.3)	0 (0.0)	5 (27.8)	3 (100.0)		
Sex	Male	27 (61.4)	22 (62.9)	5 (27.8)	3 (100.0)	3.366	0.125
	Female	17 (38.6)	13 (37.1)	13 (72.0)	0 (0.0)		
Occupation	Hard work	8 (18.2)	0 (0.0)	3 (16.7)	0 (0.0)	29.718	0.062
	Housewife	5 (11.4)	5 (14.3)	0 (0.0)	0 (0.0)		
	Light work	5 (11.4)	5 (14.3)	1 (5.6)	0 (0.0)		
	Not working	15 (34.1)	17 (48.6)	9 (50.0)	3 (100.0)		
	Self-work	0 (0.0)	0 (0.0)	3 (16.7)	0 (0.0)		
	Student	11 (25.0)	8 (22.9)	2 (11.1)	0 (0.0)		
Onset of Illness	< 5 yrs	21 (47.7)	0 (0.0)	0 (0.0)	0 (0.0)	82.577	**0.001***
	5-10 yrs	14 (31.8)	10 (28.6)	3 (16.7)	0 (0.0)		
	10-20 yrs	9 (20.5)	20 (57.1)	2 (11.1)	0 (0.0)		
	> 20 yrs	0 (0.0)	5 (14.3)	13 (72.2)	3 (100.0)		
Number of Relapses	< 3	29 (65.9)	5 (14.3)	3 (16.7)	0 (0.0)	73.559	**0.001***
	3-6	13 (29.5)	30 (85.7)	6 (33.3)	0 (0.0)		
	> 7	2 (4.5)	0 (0.0)	9 (50.0)	3 (100.0)		
Time Since Last Relapse	< 12 months	32 (72.7)	22 (62.9)	5 (27.8)	3 (100.0)	12.946	**0.005***
	> 12 months	12 (27.3)	13 (37.1)	13 (72.2)	0 (0.0)		
Family History	No	36 (81.8)	27 (77.1)	14 (77.8)	0 (0.0)	10.627	**0.014***
	Yes	8 (18.2)	8 (22.9)	4 (22.2)	3 (100.0)		

Note: Percentages represent column percentages. P-values < 0.05 are considered significant.

3.2 Discussion

This study provides the first systematic investigation into the prevalence and correlates of functional impairment and disability among euthymic Libyan adults with bipolar disorder. The primary finding is that most patients experience persistent functional deficits despite achieving symptomatic remission. More than half of the sample (56%) exhibited some degree of functional impairment, and nearly two-thirds (65%) reported experiencing disability. This illustrates the critical gap between clinical stabilization and real-world recovery, reinforcing the notion that symptom control is a necessary but insufficient goal in the comprehensive management of BPD.

Findings are consistent with a large body of international research demonstrating that functional recovery lags significantly behind syndromal recovery in BPD (Judd et al., 2005; Khan et al., 2016). For example, Judd et al. (2005), found that even during periods of euthymia, individuals with BPD spend a significant amount of time with psychosocial impairment. The prevalence rates of impairment in the Libyan sample align broadly with those reported in Western cohorts, suggesting that the challenge of residual functional deficits is a universal feature of the illness. The strong positive correlation observed between scores on the FAST and

WHODAS ($p < 0.001$) further validates these findings, showing a robust link between clinician-rated functional capacity and patient-reported disability across multiple life domains.

The identification of specific correlates of poor functioning provides valuable insights for risk stratification and intervention planning. The association of worse outcomes with older age, a longer duration of illness, and a greater number of relapses supports a "neuroprogression" model of BPD, wherein the cumulative burden of mood episodes may lead to enduring changes in neural circuits that underpin cognitive and social functioning (Chaudhury et al., 2006). This underscores the critical importance of early intervention and aggressive relapse prevention strategies to preserve long-term function. Furthermore, the strong link between unemployment and poor outcomes highlights a key area for targeted support. While unemployment may be a consequence of functional impairment, it is also a powerful driver of further disability, social isolation, and low self-esteem. This bidirectional relationship suggests that vocational rehabilitation should be a core component of BPD care.

The significant association between a positive family history and poorer functional outcomes is another noteworthy finding. This may reflect a higher genetic loading for a more severe illness phenotype or the influence of a shared environment that is less conducive to recovery. This finding warrants further investigation but suggests that patients with a dense family history of psychiatric illness may require more intensive monitoring and psychosocial support (McDermott & Turk, 2011).

Clinical Implications

The results of this study have direct implications for clinical practice in Libya and similar settings. First, mental health services must shift from a purely symptom-focused model to a broader, recovery-oriented framework that prioritizes functional outcomes. Clinicians should routinely assess functioning using standardized tools like the FAST as part of standard care. Second, the findings highlight an urgent need for the development and implementation of evidence-based psychosocial interventions, such as cognitive remediation, social skills training, and individual placement and support (IPS) models of vocational rehabilitation. These interventions are specifically designed to address the functional deficits that persist during euthymia and are critical for helping patients achieve meaningful personal and occupational goals.

Strengths and Limitations

The primary strength of this study is that it is the first of its kind to be conducted in a Libyan population, providing novel and locally relevant data. The use of standardized, validated instruments and clear, operationalized criteria for euthymia enhances the methodological rigor. However, several limitations must be acknowledged. First, the cross-sectional design precludes any inferences of causality; for example, it cannot determine whether unemployment precedes or results from functional impairment. Second, the sample was recruited from specialized outpatient clinics, which may not be representative of all individuals with BPD in the community, particularly those who are not engaged in care. Third, the very small number of participants with Bipolar II Disorder (n=3) prevented any meaningful comparison between BPD subtypes. Finally, the study did not control for potential confounders such as medication type and adherence, cognitive performance, or comorbid substance use, which may also influence functional outcomes.

Future Directions

Future research should employ longitudinal designs to track the trajectory of functional recovery over time and to delineate causal relationships between clinical variables and outcomes. Larger, multi-center studies are needed to compare functional profiles between Bipolar I and Bipolar II disorders more robustly. Finally, intervention studies are crucial to test the feasibility and effectiveness of psychosocial and vocational rehabilitation programs within the Libyan healthcare context.

4 Conclusion

This study provides the first empirical evidence from Libya demonstrating that a significant majority of patients with bipolar disorder experience persistent functional impairment and disability, despite achieving syndromal remission. Key determinants of poor functional outcomes include a more chronic and relapsing illness course, unemployment, and a positive family history of psychiatric illness. These findings underscore the critical need to expand the focus of clinical management in BPD beyond symptom control. A recovery-oriented approach, incorporating routine functional assessment and targeted psychosocial and vocational interventions, is essential to address the profound real-world deficits that remain a core challenge of the illness.

Declarations

Ethics Approval and Consent to Participate
This study was conducted in accordance with the principles of the Declaration of Helsinki. The research protocol was reviewed and approved by the Ethics Committee of the Faculty of Medicine, Al-Asmarya Islamic University. All participants were provided with a detailed explanation of the study's objectives and procedures. Written informed consent was obtained from all participants before their inclusion in the study. For participants under the age of 18, informed consent was obtained from a parent or legal guardian.

Consent for Publication
Not applicable. This manuscript does not contain any person’s data in any form (including individual details, images, or videos).

Availability of Data and Materials
The datasets generated and/or analysed during the current study are not publicly available due to patient privacy and confidentiality concerns, but are available from the corresponding author on reasonable request.

Competing Interests
The authors declare that they have no competing interests.

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Authors' Contributions
E.A.M.A. conceptualized and designed the study, collected the data, performed the data analysis, and drafted the initial manuscript. N.S.A. supervised the project, contributed to the study design and data interpretation, and critically revised the manuscript for important intellectual content. Both authors read and approved the final manuscript.

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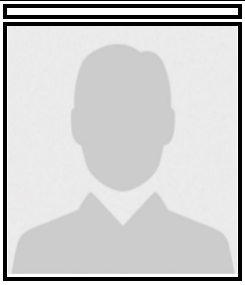
Biography of Authors



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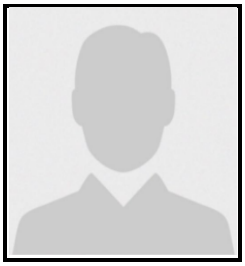

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