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ORIGINAL RESEARCH

Pain, functional independence, and psychological distress as determinants of health-related quality of life in post-acute recovery phase following extremity injury

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Abstract

Background: Extremity trauma is a leading cause of hospital admissions worldwide and significantly impacts post-acute recovery and quality of life. While acute trauma management is well-documented, the post-acute recovery phase remains understudied despite its critical role in long-term outcomes. Identifying determinants of quality of life during this period is essential for optimizing and guiding recovery strategies. This study aimed to investigate correlations between health-related quality of life and key determinants, including demographic characteristics, pain, functional independence and psychological distress, during the post-acute recovery phase following extremity injury. **Methods**: This cross-sectional study enrolled 70 patients with extremity trauma and was conducted over a year at an outpatient clinic of a tertiary hospital in Taiwan. Pain intensity, functional independence, psychological distress and health-related quality of life were assessed using the numeric pain rating scale, Barthel Index, brief symptom rating scale, and the EuroQoL 5-Dimensions questionnaire, respectively. Multiple linear regression analysis was performed to identify determinants of quality of life. **Results**: Regression analysis demonstrated significant associations between poorer quality of life and higher pain intensity ($\beta = 0.31$, $p < 0.001$), greater psychological distress ($\beta = 0.20$, $p = 0.008$), older age ($\beta = 0.27$, $p = 0.049$) and injuries from vehicle accidents ($\beta = 0.24$, $p = 0.016$). Conversely, greater functional independence was significantly correlated with improved quality of life ($\beta = -0.57$, $p < 0.001$). **Conclusions**: This study found significant correlations between health-related quality of life and factors such as pain intensity, psychological distress, functional independence, age and injury mechanism. These findings emphasize the importance of comprehensive care strategies integrating effective pain management, psychological interventions and functional rehabilitation during the post-acute recovery period. Future longitudinal and multi-site studies are recommended to further examine causal relationships and enhance the generalizability of these findings.

Keywords

Extremity injury; Pain; Stress; Quality of life; Functional status; Regression analysis; Rehabilitation; Cross-sectional studies

1. Introduction

Trauma is a significant public health concern worldwide, contributing to a substantial morbidity, disability, and socioeconomic burden. The World Health Organization (WHO) reports that trauma accounts for 10% of global mortality, with millions of people suffering from severe injuries annually [1]. Extremity trauma, which includes fractures, dislocations, and soft tissue injuries, is among the most common traumatic injuries and can lead to long-term disability and reduced health-related quality of life (HQoL) [2]. While trauma-related deaths have been widely studied, the post-acute recovery phase, the critical period following hospital discharge, remains underexplored, particularly in relation to factors that predict long-term health outcomes and HQoL.

The burden of trauma varies across regions, but extremity injuries remain a leading cause of hospital admissions worldwide. In the United States, an analysis of the National Trauma Data Bank showed that 42.8% of trauma cases were classified as mild (Injury Severity Score (ISS) of 1–8), 37.7% as moderate (ISS of 9–15), and 21.2% as severe (ISS of $\geq$16) [3]. In a study of trauma cases in India, upper and lower limb injuries accounted for 29% and 11%, respectively. Notably, limb fractures were present in approximately 30% of all trauma cases [4]. Similar trends are observed in Europe, where extremity

trauma comprises around 50% of major trauma admissions [5]. In Asia, motor vehicle accidents remain the predominant cause of trauma, with limb fractures accounting for a quarter of all injuries [6]. This high prevalence of extremity trauma not only contributes to substantial healthcare use, but also leads to potentially prolonged physical, psychological, and social consequences that impair recovery and overall HQoL.

Pain is one of the most persistent complications following extremity trauma, significantly impacting post-acute recovery and HQoL. Trauma patients experience pain at discharge, with reports of moderate to severe pain [7]. Even one year after injury, patients continue to experience pain, which can interfere with functional independence, rehabilitation progress, and return to daily activities [8]. Poorly managed or unresolved pain has been linked to delayed mobility, prolonged disability, and higher psychological distress, further exacerbating recovery challenges [7, 9]. Given its profound effects on physical function and emotional well-being, understanding how the level of pain experienced after discharge specifically influences HQoL is crucial for guiding effective pain management strategies. However, despite its prevalence, pain remains underexplored as a determinant of HQoL during the post-acute recovery phase, warranting further investigation.

Psychological distress is a significant yet often overlooked consequence of extremity trauma, with symptoms of anxiety, depression, and emotional instability persisting well beyond the initial injury phase [7]. The psychological burden of trauma is closely linked to pain perception, reduced functional independence, and poorer HQoL outcomes [9]. Trauma survivors experience clinically significant psychological distress within the first month after injury [10], which can potentially delay rehabilitation and return to daily activities. Despite these findings, few studies have examined the role of psychological distress as a determinant of post-acute HQoL in trauma populations. Addressing this gap is critical, as early identification of psychological distress may enable targeted interventions that promote both physical and emotional recovery.

In addition, functional independence plays a crucial role in post-acute recovery from extremity trauma [11], influencing patients' ability to regain mobility, perform daily activities, and return to pre-injury levels of functioning. Only some individuals with moderate-to-severe musculoskeletal injuries may successfully return to work within a year after injury, with average work absence exceeding 100 days [12]. In Europe, workplace-related extremity injuries account for some occupational disabilities, further highlighting the economic consequences of trauma. Reduced functional independence not only prolongs recovery but also diminishes overall HQoL [13], as patients with greater dependence on assistance face increased psychological distress and lower social participation. Given these challenges, evaluating functional independence as a determinant of post-acute HQoL is essential for optimizing rehabilitation strategies and guiding patient-centered care.

Post-injury HQoL is a key outcome of trauma recovery, as it reflects patients' physical, psychological, and social adaptation after injury. Studies show that HQoL remains impaired for at least six months after injury, with patients reporting work-related difficulties, experiencing financial challenges, and struggling with social-emotional issues [13–15]. In the United States, a longitudinal study found that HQoL does not return to pre-injury levels even five years after trauma, especially in cases *involving* severe fractures or multiple limb injuries [16]. Given these long-term consequences, identifying factors that predict post-acute HQoL is essential for optimizing rehabilitation strategies and improving patient outcomes.

Despite extensive research on acute trauma management, determinants of HQoL during the post-acute phase remain poorly understood [17]. Most studies have focused on physical symptoms within the first three months after injury [18], or long-term disability beyond one year [19]. However, the critical transition period immediately following hospital discharge, often referred to as the post-acute recovery phase, has received limited empirical attention. In Asia, particularly Taiwan, where trauma predominantly affects older adults due to its super-ageing society, understanding the factors influencing HQoL during this period is essential for guiding clinical care, resource allocation, and rehabilitation planning to optimize patient outcomes [20].

Given these gaps, this study aimed to investigate the correlations between HQoL and key determinants, including demographic characteristics, pain, functional independence, and psychological distress, during the post-acute recovery phase following extremity injury. Specifically, this study hypothesized that higher pain intensity, greater psychological distress, and higher functional independence are positively correlated with improved HQoL.

2. Methods

2.1 Study design

This study employed a correlational design with a cross-sectional approach to investigating the relationships between demographic factors, injury-related variables, psychological factors, and HQoL of trauma patients. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline was followed in reporting this study [21].

2.2 Participants and setting

Participants were recruited using convenience sampling from trauma outpatient clinics of a tertiary hospital, where patients with physical trauma were admitted, between May 2023 and May 2024. Eligible participants met the following inclusion criteria: (1) first-time physical trauma resulting from an accident; (2) within a month after discharge; (3) aged 20 to 85 years; and (4) absence of major comorbidities or government-issued serious illness certification. Patients were excluded if they (1) had sustained severe trauma at the time of injury; (2) had a spinal cord injury; (3) sustained trauma from non-accidental causes such as self-harm; or (4) had a diagnosed mental illness. The sample size of 70 participants was determined by conducting a power analysis using G*Power 3.1.9.7 software (Heinrich Heine University Düsseldorf, Düsseldorf, NRW, Germany). The analysis applied a Type I error of 0.05, statistical power of 0.8, and assumed a large effect size. A sample of this size was considered sufficient given the cross-sectional study design and the exploratory nature

of the research question, which aimed to identify significant determinants of HQoL. Additionally, considering the specificity of the population and practical constraints of participant recruitment in a clinical setting, this sample size provided adequate statistical power to detect meaningful relationships between study variables.

2.3 Measures

2.3.1 Demographic and clinical characteristics

Data on age, gender, marital status, education level, injury severity and length of hospitalization were collected from medical records and interviews.

2.3.2 Numeric pain rating scale

Pain intensity was measured using the Numeric Pain Rating Scale, ranging from 0 (no pain) to 10 (worst possible pain). Scores of 1–3 indicated mild pain, 4–6 moderate pain and 7–10 severe pain [22].

2.3.3 Barthel index

The Barthel Index was used to assess functional disability based on activities of daily living, with scores ranging from 0 to 100. Higher scores indicated greater independence: 0–20 (total dependence), 21–60 (severe dependence), 61–90 (moderate dependence), 91–99 (mild dependence) and 100 (complete independence) [23]. Cronbach's alpha of this assessment was 0.85.

2.3.4 Brief symptom rating scale

The Brief Symptom Rating Scale (BSRS-5) was used to assess psychological distress across five domains—anxiety, anger, depression, low self-esteem, and insomnia—rated on a 5-point Likert scale. A sixth item assessed suicidal ideation. Higher scores indicated more significant psychological distress [24]. Cronbach's alpha of this assessment was 0.79.

2.3.5 EuroQol 5-Dimensions

The EuroQol 5-Dimensions (EQ-5D) questionnaire assessed HQoL across five dimensions: mobility, self-care, daily activities, pain/discomfort, and anxiety/depression. Responses were categorized as none, moderate or extreme. The score was calculated using the level sum score method [25], with higher scores indicating worse health conditions. Cronbach's alpha of this assessment was 0.76.

2.3.6 Data collection

Participants were recruited through trauma outpatient clinics within a month after discharge, representing the post-acute recovery phase. Trained researchers identified potential participants via hospital records and obtained written informed consent before enrollment. Data were collected through face-to-face interviews in a private outpatient setting between 25 May 2023 and 24 May 2024. The study ensured standardized administration of instruments to reduce bias. Missing data were addressed by verifying responses in real time during data collection in order to minimize incomplete responses. This study employed listwise deletion if data remained missing.

2.3.7 Data analysis

Statistical analyses were performed using SPSS version 22.0 (IBM Corp, Armonk, NY, USA). Descriptive statistics summarized participant characteristics and studied variables using frequency (n), mean (M) and standard deviation (SD). Multiple linear regression analysis was performed using the forced-entry method to identify determinants of HQoL. Unstandardized regression coefficients (B), standardized coefficients (β), and 95% confidence intervals (CIs) were calculated to evaluate the strength and precision of each determinant's effect. CIs were used to determine the precision of estimates and assess whether the associations identified could be considered statistically robust. A significant threshold of $p < 0.05$ was applied.

3. Results

3.1 Participant characteristics

This study enrolled 70 trauma patients with a mean age of 65.81 (SD = 17.64) years. The majority of the participants were male (57.14%). Most participants (60.00%) had an education level of less than 12 years and were partnered (71.43%). Falls were the primary mechanism of injury (64.29%), and lower limb injuries predominated (92.86%). Nearly all participants (95.71%) underwent surgery, with a mean hospital stay of 8.00 (SD = 3.09) days. The mean score for pain intensity was 3.57 (SD = 2.06), independence averaged 56.07 (SD = 23.19), and the mean score for psychological distress was 1.91 (SD = 2.60). The mean score for HQoL, measured using the EQ-5D, was 8.83 (SD = 1.80) (Table 1).

3.2 Determinants of quality of life

A multiple linear regression model used to identify significant determinants of HQoL explained 70% of the variance ($F(10, 59) = 13.73$, $p < 0.001$; Table 2). Significant determinants included age ($\beta = 0.27$, $p = 0.049$, 95% CI = 0.00, 0.06), indicating older age was associated with poorer HQoL. Injury mechanism (vehicle accidents *vs.* falls) was significantly associated with worse HQoL ($\beta = 0.24$, $p = 0.016$, 95% CI = 0.18, 1.64). Higher pain intensity ($\beta = 0.31$, $p < 0.001$, 95% CI = 0.13, 0.41) and psychological distress ($\beta = 0.20$, $p = 0.008$, 95% CI = 0.04, 0.25) were associated with poorer HQoL, whereas greater functional independence ($\beta = -0.57$, $p < 0.001$, 95% CI = −0.06, −0.03) was associated with better HQoL. The confidence intervals of all significant determinants did not cross zero, indicating robust and precise estimations of these associations (Fig. 1). All prespecified covariates were entered via forced-entry and retained in the model; gender, education, marital status, injury severity score, and length of stay were not statistically significant (all $p > 0.05$).

4. Discussion

This study aimed to identify determinants of HQoL in the post-acute recovery phase following extremity injury. The findings provide valuable insights into how demographic, clinical, and psychological factors contribute to recovery outcomes and offer empirical evidence for enhancing trauma care and rehabilitation strategies. Our results showed that older age,

TABLE 1. Demographic and clinical characteristics of the trauma patients.

Variable	Mean	SD	n	%
Age	65.81	17.64		
Gender				
Female			30	42.86
Male			40	57.14
Education				
≥12 yr			28	40.00
<12 yr			42	60.00
Marital status				
Partnered			50	71.43
Unpartnered			20	28.57
Living alone				
No			65	92.86
Yes			5	7.14
Injury mechanism				
Fall			45	64.29
Vehicle accident			25	35.71
Injury location				
Upper limbs			5	7.14
Lower limbs			65	92.86
Injury severity score	9.63	2.54		
Surgery				
Yes			67	95.71
No			1	1.43
Length of hospital stay	8.00	3.09		
ICU admission				
No			68	97.14
Yes			2	2.86
Pain intensity	3.57	2.06		
Functional independence	56.07	23.19		
Psychological distress	1.91	2.60		
Quality of life	8.83	1.80		

Note: SD: standard deviation; n: frequency; ICU: intensive care unit.

injury from vehicle accidents, higher pain intensity, and greater psychological distress were associated with poorer HQoL, while greater functional independence was linked to better HQoL. These findings align with the results of previous studies and highlight the multifaceted nature of trauma recovery.

Pain was one of the strongest determinants of HQoL in our study, with higher pain intensity significantly associated with worse HQoL outcomes. This result is consistent with previous findings indicating that pain is a major determinant of long-term functional outcomes following extremity trauma [8]. Pain persists in a significant proportion of trauma patients, with patients still experiencing pain a year after injury [26]. Pain affects daily functioning, limits mobility and contributes to psychological distress, which in turn worsens overall well-being [27]. Our findings reinforce the need for early and effective pain management strategies in post-acute trauma care, as poorly controlled pain can have prolonged adverse effects on physical and psychological recovery.

Psychological distress also emerged as a significant factor affecting HQoL, with higher levels of distress associated with worse HQoL scores. Psychological distress, including symptoms of anxiety, depression, and emotional instability, is commonly reported by trauma patients [7]. The psychological impact of trauma often extends beyond physical injuries, contributing to reduced motivation for rehabilitation, social withdrawal, and increased vulnerability to Post-Traumatic Stress

TABLE 2. Determinants of quality of life.

Variable	B	SE	95% CI	β	*t*	*p*
(Intercept)	6.67	1.35	[3.96, 9.38]	0.00	4.93	<0.001
Age	0.03	0.01	[0.00, 0.06]	0.27	2.01	0.049
Gender (Ref: Male)	0.33	0.28	[−0.23, 0.89]	0.09	1.18	0.244
Education (Ref: ≥12 yr)	0.40	0.36	[−0.32, 1.12]	0.11	1.12	0.267
Marital status (Ref: Unpartnered)	−0.04	0.39	[−0.83, 0.75]	−0.01	−0.11	0.914
Injury mechanism (Ref: vehicle accident)	0.91	0.37	[0.18, 1.64]	0.24	2.49	0.016
Injury severity score	0.08	0.06	[−0.04, 0.20]	0.11	1.30	0.198
Length of stay	0.01	0.05	[−0.08, 0.10]	0.01	0.18	0.859
Pain intensity	0.27	0.07	[0.13, 0.41]	0.31	3.92	<0.001
Functional independence	−0.04	0.01	[−0.06, −0.03]	−0.57	−6.33	<0.001
Psychological distress	0.14	0.05	[0.04, 0.25]	0.20	2.74	0.008

Note: Results: $F(10, 59) = 13.73$, $p < 0.001$, $R^2 = 0.70$. SE: standard error; CI: confidence interval.

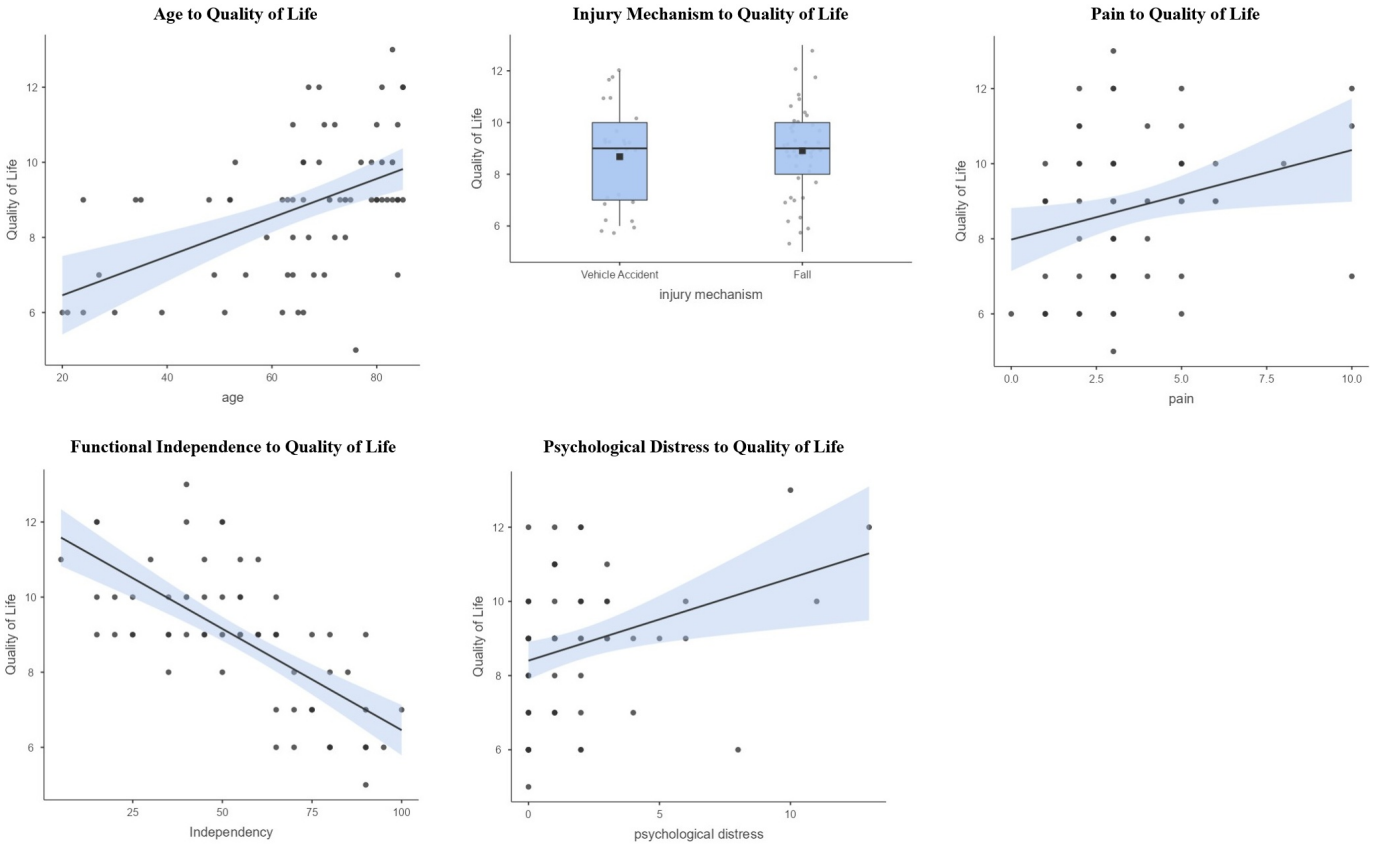

FIGURE 1. Determinants of health-related quality of life.

Disorder (PTSD) [26]. The role of psychological distress in moderating HQoL outcomes underscores the importance of integrating mental health support into post-trauma care. Routine psychological assessments and early interventions, such as cognitive-behavioral therapy or trauma-focused counselling, may be beneficial in improving long-term recovery outcomes.

Functional independence was found to be a protective factor of HQoL, with greater independence associated with improved HQoL scores. This finding aligns with the results of a previous study indicating that mobility and self-care capacity are crucial determinants of long-term well-being after trauma [28]. Patients who regain independence more rapidly experience fewer limitations in daily activities, which enhances their psychological well-being and social participation. However, many trauma patients face prolonged functional impairment, with studies reporting that up to one-third of individuals do not return to work within a year after injury [12]. Given these challenges, targeted rehabilitation programs that promote mobility and self-care skills are essential for optimizing recovery and enhancing HQoL.

Age was a significant determinant of HQoL, with older patients reporting poorer outcomes. This finding is in line with a previous study indicating that older adults face greater challenges in trauma recovery due to age-related physiological changes, comorbidities, and slower wound healing [29]. Older trauma patients often experience prolonged hospital stays, delayed functional recovery, and increased risk of complications, all of which contribute to reduced HQoL [4]. The association between age and HQoL highlights the importance of age-specific rehabilitation strategies that address the unique needs of older trauma patients.

Injury mechanism also played a role in predicting HQoL, with patients injured in vehicle accidents reporting worse outcomes compared to those who sustained falls. Motor vehicle accidents are known to cause more severe musculoskeletal injuries, leading to prolonged disability and increased psychological distress [6]. The greater severity of injuries caused by vehicle accidents may explain the lower HQoL scores observed in this group. Understanding these associations can aid in tailoring rehabilitation interventions based on the nature of the injury and its impact on recovery.

The findings of this study have several clinical implications for improving trauma recovery and patient-centered care. First, effective pain management should be prioritized as a key component of post-acute trauma care. Given the persistence of pain in trauma patients, multimodal pain management strategies incorporating pharmacological treatments, physical therapy, and psychological support should be integrated into routine clinical practice. Addressing pain early in the recovery process may prevent long-term disability and enhance overall well-being. Second, psychological support should be incorporated into trauma rehabilitation programs. The significant impact of psychological distress on HQoL underscores the need for early mental health screening and intervention. Trauma-informed counselling, psychoeducation, and social support services may help patients cope with the emotional burden of their injuries and improve their overall recovery experience. Third, rehabilitation efforts should focus on promoting functional independence. Enhancement of mobility and self-care skills through structured physical therapy programs can facilitate faster recovery and improve long-term HQoL. Individualized rehabilitation plans that account for patients' specific needs and recovery goals may yield better functional and psychological outcomes. Finally, older trauma patients and those with injuries caused by vehicle accidents may require additional support during recovery. Considering older patients' physiological and cognitive challenges, age-specific rehabilitation approaches can help optimize functional outcomes. Similarly, patients with severe trauma resulting from vehicle accidents may benefit from more intensive physical and psychological rehabilitation programs.

This study contributes to the growing body of research on trauma recovery by identifying key determinants of HQoL during the post-acute phase. The use of validated measurement tools and a robust analytical approach enhanced the reliability of the findings. However, the cross-sectional design limited the ability to establish causal relationships between the variables studied. Longitudinal studies are necessary to clarify how factors such as pain intensity, psychological distress, and functional independence influence HQoL over time. Additionally, expanding the study to include multiple trauma centers and more diverse populations would improve the generalizability and external validity of these findings. While this study provides valuable insights, further investigation is needed to explore the potential causal mechanisms underlying these associations. Pain and psychological distress may negatively impact HQoL by restricting physical activity, impeding rehabilitation efforts, and contributing to social isolation. In contrast, functional independence is likely to enhance HQoL by fostering self-efficacy, emotional well-being, and greater social participation. However, these proposed mechanisms remain speculative and should be tested in future studies.

Selection, feasibility, and measurement biases warrant consideration. Recruitment was challenging within a prespecified one-year window at a single tertiary hospital. Strict eligibility criteria (first-time accidental trauma, within one month of discharge, absence of major comorbidities) and the relatively older profile of the clinic population meant that few patients met the criteria or were available to participate. Despite continuous screening, only 70 eligible patients consented and completed assessments. This feasibility-bound, single-center convenience sample may introduce selection bias and limit precision and generalizability to the broader trauma population. Additionally, reliance on self-reported measures for pain, psychological distress and HQoL increases the risk of measurement bias due to subjective interpretations and social desirability effects. While validated instruments were used to mitigate these concerns, such biases cannot be entirely eliminated. Future studies should adopt longitudinal designs, incorporate a broader range of trauma centers, and use objective measures where possible to strengthen the validity and applicability of findings across diverse healthcare settings.

5. Conclusions

This study highlights the complex interplay of pain intensity, psychological distress, functional independence, age, and injury mechanism in determining HQoL during the post-acute recovery phase following extremity injury. The findings emphasize the importance of comprehensive trauma care strategies, highlighting that clinicians should prioritize effective pain management, psychological support interventions, and targeted rehabilitation aimed at enhancing functional independence. Despite these valuable insights, the cross-sectional and single-site nature of this study limits causal interpretations and generalizability of the findings. Future studies should incorporate longitudinal designs to clearly establish causal relationships and multi-site investigations to enhance external validity.

ABBREVIATIONS

HQoL, Health-related quality of life; ISS, Injury Severity Score; STROBE, Strengthening the Reporting of Observational Studies in Epidemiology; BSRS, Brief Symptom Rating Scale; EQ-5D, EuroQol 5-Dimensions; SD, standard deviation; CI, confidence interval; IRB, Institutional Review Board; PTSD, Post-Traumatic Stress Disorder.

AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are available from the corresponding author upon reasonable request.

AUTHOR CONTRIBUTIONS

MCL, BOL and SIT—designed the study. MCL and BOL—conducted the study. SIT and MM—advised on data curation and analysis. MCL, BOL, MM and SIT—wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study followed the ethical principles outlined in the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of Madou Sin-Lau Hospital (IRB serial No. SLH-112-A-002). Written informed consent was obtained from all participants, ensuring their voluntary participation. Participants were assured of their right to withdraw from the study at any time without consequences.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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