Research Square

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What Is Important to Patients Who Are Recovering from Elbow Fractures?

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Abstract

Purpose: This study aimed to evaluate postoperative upper limb function and health-related quality of life (HRQoL) in patients who underwent surgical treatment for elbow fractures, and to identify demographic and clinical factors associated with recovery outcomes.

Materials and Methods: A cross-sectional survey was conducted among 36 adult patients following elbow fracture surgery at Nottingham University Hospitals between July 2022 and July 2024. Patient-reported outcomes were assessed using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire and the EuroQol 5-Dimension 5-Level (EQ-5D-5L) instrument. Statistical analyses included descriptive statistics, non-parametric tests, and exploratory regression modelling.

Results: The median DASH score was 10.3, indicating generally favourable functional recovery. Manual workers demonstrated significantly better DASH scores compared to non-manual workers (p=0.031). The median EQ-5D-5L index was 0.34, and the EQ-VAS score was 75.0. Patients without comorbidities had significantly higher EQ-VAS scores (p=0.029). No significant correlation was observed between DASH and EQ-5D-5L scores, suggesting these tools capture distinct dimensions of recovery.

Conclusion: Postoperative recovery after elbow fracture is influenced by occupational demands and comorbidity status. Functional outcomes and HRQoL represent separate recovery domains, highlighting the value of multidimensional assessment in clinical practice.

1 Introduction

1.1 Epidemiology and Mechanism of Elbow Fractures

Elbow fractures account for approximately 4.3% of all fractures[1]. They primarily involve three anatomical regions: the distal humerus, the proximal ulna, and the proximal radius. A seven-year retrospective study conducted by a Level I trauma centre in the United Kingdom reported annual incidence rates ranging from 10 to 21 per 100,000 population for these three types, respectively, forming the major clinical categories of elbow fractures[2]. Among all injury mechanisms, the most frequent is a fall onto an outstretched hand[3], and the olecranon fracture is considered the most common single type[4]. The incidence pattern of these fractures typically exhibits a bimodal distribution: high-energy trauma (e.g., traffic accidents) predominates among younger individuals, whereas older patients are more susceptible to fractures caused by low-energy falls related to osteoporosis[5]. With the growing trend of population aging, the incidence of elbow fractures in older adults continues to rise, placing increased demands on postoperative care within healthcare systems.

1.2 Functional Consequences of Elbow Injuries

Elbow injuries significantly impair upper limb function and activities of daily living (ADLs)[6, 7]. The elbow plays a crucial role in functional positioning of the forearm, wrist, and hand in space. Even mild functional limitations of the elbow may markedly reduce upper limb precision[8]. As the joint connecting

the upper arm and forearm, the elbow enables flexion-extension and forearm rotation, and serves as a critical structure for multidirectional movement and force transmission. Common ADLs such as bringing objects to the mouth and writing all rely on normal elbow function[9]. Therefore, impairment of elbow function can profoundly affect self-care abilities and social participation, particularly in elderly individuals[10]. Moreover, the elbow is known for its bony congruency, but after injury, the thickened and tense joint capsule may cause contractures and stiffness, further prolonging recovery and affecting long-term outcomes[11].

1.3 Challenges in Postoperative Recovery

Evidence suggests that surgical treatment of elbow fractures generally yields good functional outcomes, with high satisfaction scores on instruments such as the Disabilities of the Arm, Shoulder and Hand (DASH) and Mayo Elbow Performance (MEP) scales[12]. However, certain complex fracture types may still result in persistent functional limitations and restricted range of motion. Postoperative recovery is shaped by a multifactorial interplay involving patient age, comorbidities, fracture characteristics and adherence to rehabilitation. This multifactorial complexity presents challenges for clinical decision-making and prognosis prediction. Additionally, complications such as joint deformity, instability, heterotopic ossification, and chronic pain may further impede recovery[13]. Given these multifactorial challenges, it becomes increasingly important to adopt a more holistic approach to evaluating recovery.

1.4 Limitations of Conventional Assessment

Although functional recovery remains a key indicator in postoperative evaluation, studies have shown that relying solely on objective clinical scores often fails to capture patients' subjective recovery experience and overall health status. With the increasing emphasis on patient-centered outcomes, Patient-reported outcome measures (PROMs) have emerged as essential complements in postoperative assessment[14]. Among these, Health-related quality of life (HRQoL)—which reflects subjective dimensions such as pain, emotional well-being, and independence in daily life—has gained growing importance in fracture rehabilitation[15]. Nonetheless, current research on elbow fractures remains largely focused on functional outcomes, with limited exploration of patients' subjective recovery experience or relevant intervention strategies, and often constrained by small samples and methodological inconsistencies, which restricts a comprehensive understanding of postoperative recovery patterns[16, 17].

1.5 Toward a Multidimensional Recovery Framework

While the importance of patient-centered outcomes has been increasingly recognized, high-quality research in this area remains scarce. Existing studies are often limited in scope—typically small in sample size and focused narrowly on clinical or radiographic outcomes, offering limited insight into the lived recovery experiences of patients.

In light of these evidence gaps, there is a clear rationale for adopting a structured, multidimensional framework to evaluate recovery. The Wilson & Cleary model provides a seminal conceptual framework that links biological, symptom, functional, and HRQoL domains, emphasizing their interrelationships rather than viewing them in isolation[18]. Concurrently, methodological initiatives such as the Core Outcome Domains for Elbow Replacement (CODER) study highlight the growing consensus on the need to standardize patient-centered outcome assessment in major elbow surgeries[19]. This study responds to these conceptual and methodological calls. By concurrently employing the DASH (targeting function) and EQ-5D-5L (targeting HRQoL) instruments, it aims to capture distinct yet interconnected dimensions of recovery in elbow fracture patients, thereby contributing to a more holistic understanding of postoperative success.

2 Method

2.1 Study Design and Population

This study adopted a cross-sectional design and retrospectively reviewed the clinical records of consecutive adult inpatients who underwent surgical treatment for elbow fractures at Nottingham University Hospitals between July 1, 2022 and July 1, 2024.

Inclusion criteria were as follows:

1. Age≥18 years;
2. Diagnosis of elbow fracture, including distal humerus, radial head, olecranon, coronoid process fractures, as well as complex elbow fractures;
3. Completion of surgical treatment.

A total of 145 patients were initially identified based on these criteria. After further screening, 17 patients were excluded for the following reasons:

1. Incomplete or ambiguous clinical or surgical records, rendering reliable classification or outcome analysis impossible;
2. Cognitive or language impairments that prevented independent completion of the questionnaire;
3. Deceased at the time of questionnaire distribution;
4. Aged 85 years or residing in long-term care facilities, to avoid potential distress and respect ethical considerations for vulnerable individuals.

In total, questionnaires were mailed to 128 eligible patients. The flow of patient identification, screening, and questionnaire distribution is presented in Figure 1. Ultimately, 36 completed questionnaires were returned (response rate 28.1%), with valid DASH data available for 34 participants and valid EQ-5D-5L data for 35.

2.2 Data Source and Cleaning Procedures

The patient list used in this study was obtained through a structured keyword search of the trauma registry at Nottingham University Hospitals, conducted by authorised clinical personnel. Prior to data extraction, all cases were fully anonymised and assigned unique study codes. The Excel dataset received by the researcher contained no personally identifiable information, such as names, dates of birth, or hospital numbers. During questionnaire distribution, only these anonymised study codes were used to label each mailing, ensuring strict confidentiality and full compliance with ethical and institutional standards.

Before conducting statistical analyses, the dataset underwent systematic cleaning by the researcher to improve completeness and usability. This process included screening for duplicate entries, identifying and resolving inconsistencies across variables (e.g., matching fracture types with reported injury mechanisms), standardising diagnostic terminology (e.g., merging clinically synonymous labels), and coding categorical variables for analysis. Missing data were also systematically reviewed, and the corresponding handling strategies are described in the Statistical Analysis section. These procedures ensured the reliability of the dataset and provided a robust foundation for subsequent analysis.

2.3 Data Collection Tools and Procedures

Patient characteristics and recovery outcomes were assessed using mailed, anonymized questionnaires. This was a cross-sectional study, and the time since surgery varied across participants. While this design limits longitudinal interpretation, stratified analysis by follow-up duration may still offer valuable insight into recovery patterns. The questionnaire consisted of 3 parts:

1. Basic demographic and clinical information, including sex, age, occupation, fracture type and cause, time since surgery, and general health status (e.g., presence of chronic conditions).
2. DASH Questionnaire, a 30-item assessment tool designed to measure the impact of upper limb dysfunction on daily activities, work, and sports participation. Scores range from 0 to 100, with higher scores indicating greater disability. Although the British version of the DASH was originally validated in patients with rheumatoid arthritis, it demonstrated excellent psychometric properties, including high internal consistency (Cronbach's $\alpha > 0.90$) and test-retest reliability (ICC > 0.80), indicating strong linguistic and contextual suitability for use in UK populations[20]. Furthermore, recent research has recommended the DASH as a core outcome measure for evaluating postoperative functional recovery in patients with elbow fractures[21, 22], confirming its broad applicability and clinical relevance in studies involving elbow injuries.
3. EQ-5D-5L Questionnaire, a standardized instrument comprising five dimensions—mobility, self-care, usual activities, pain/discomfort, and anxiety/depression—and a Visual Analogue Scale (EQ-VAS) ranging from 0 to 100. The EQ-5D-5L has been widely validated across various populations, including older adults with multimorbidity and patients with fractures, and demonstrates good structural validity, test-retest reliability, and responsiveness to change[23, 24]. Given its brevity,

sensitivity to functional changes, and suitability for web-based administration, the EQ-5D-5L was selected as an appropriate tool for evaluating postoperative quality of life in this cohort.

To ensure accessibility for older patients and maximize response rates, the entire questionnaire package was distributed by mail. A prepaid return envelope was included in each mailing. This postal method was chosen based on previous findings that mail-based surveys are more effective among elderly populations than web-based alternatives, particularly in minimizing digital access barriers and improving data completeness[25, 26]. In addition, online platforms such as Microsoft Forms may present interface limitations when delivering complex, multi-item instruments like the DASH or EQ-5D-5L. These limitations are especially relevant for older adults, who may face challenges related to digital literacy, screen formatting, and navigation design. Recent studies have identified such usability concerns as potential barriers to accurate and complete electronic PROM responses in older populations[27, 28]. This further supports the decision to adopt a paper-based format in the present study.

No personally identifiable information was collected, and all responses were linked only via anonymized study numbers.

2.4 Statistical Analysis

All data were entered and organized using Microsoft Excel (version 2306, Microsoft Corp., USA), and statistical analyses were performed with SPSS software (version 28.0, IBM Corp., Armonk, NY, USA).

Normality of continuous variables was assessed using the Kolmogorov--Smirnov test, supplemented by visual inspection through histograms and Q--Q plots. The DASH score, EQ-5D-5L index, and EQ-VAS score were all found to be non-normally distributed (all $p < 0.05$). Therefore, for these primary outcomes, results were expressed as median and interquartile range (Median [IQR]). For any normally distributed variables, results were expressed as mean ± standard deviation (SD). Categorical variables were presented as frequencies and percentages (n, %).

The primary outcome measures were the DASH score, the EQ-5D-5L index, and the EQ-VAS score. The DASH score was calculated in accordance with the official scoring manual. For questionnaires with up to three missing items, the total score was derived using the average of the completed items. If more than three items were missing, the questionnaire was excluded from DASH score analysis[29]. To examine the robustness of this exclusion criterion, a sensitivity analysis was performed by extending the threshold to five missing items. This allowed for the inclusion of one additional case, increasing the total sample size from 34 to 35. The mean DASH score changed marginally from 20.88 to 21.11, and the standard deviation decreased slightly from 25.71 to 25.38, indicating that the original criterion (≤3 missing items) provided a stable and reliable basis for analysis.

The EQ-5D-5L index was derived using the UK value set, which applies a hybrid valuation model combining time trade-off (TTO) and discrete choice experiment (DCE) techniques[30]. The EQ-VAS score was obtained from participants' self-rated health on a 0–100 visual analogue scale.

Given the non-normal distribution of the primary outcomes, between-group differences for these outcomes were examined using the Mann–Whitney U test. These tests provided crude (unadjusted) comparisons between subgroups (e.g., sex, fracture type, mechanism of injury). Comparisons between categorical variables were conducted using the chi-square test or Fisher's exact test, as appropriate. Correlations involving the primary outcomes (which were non-normally distributed) were assessed using Spearman's rank correlation. Pearson's correlation was used only for associations between variables that were both normally distributed. To determine whether observed crude differences persisted after accounting for other demographic and clinical variables, exploratory multiple linear regression models were subsequently fitted. All variables were entered simultaneously using a forced-entry approach. To evaluate the statistical assumptions of linear regression, residual plots and standardised residual histograms were examined for normality, scatterplots were used to assess linearity and homoscedasticity, and variance inflation factors (VIFs) were calculated to check for multicollinearity.

All statistical tests and procedures correspond directly with those reported in the Results section to ensure transparency and consistency.

2.5 Regression Modeling Strategy and Sample Size Consideration

Prior to analysis, all demographic and clinical variables were coded as follows to facilitate correlation and regression analysis:

1. Sex was coded as 0 = Female and 1 = Male.
2. Occupation was dichotomized into non-physical work (0) and physical labor (1).
3. Comorbidity status was coded as 1 if any chronic or pre-existing condition was reported, and 0 otherwise.
4. Fracture types were represented by 3 dummy variables: 1) Radial head fracture (1 = Yes, 0 = No), 2) Olecranon fracture (1 = Yes, 0 = No), 3) Distal humerus fracture (1 = Yes, 0 = No). Patients with combined or complex injuries were not coded separately in correlation analysis but were used as the reference group in regression models.
5. Mechanism of injury was dichotomized as low-energy trauma (0, e.g., fall from standing) and high-energy trauma (1, e.g., falls from height, RTCs, and sports injuries).
6. Time since injury was treated as a continuous variable (months), as was age. Although the trauma registry initially provided age in categorical bands due to data protection requirements, exact age values were obtained from the returned questionnaires. Consequently, age was treated as a continuous variable in all correlation and regression analyses to enhance statistical precision, while categorical age groupings were retained only in descriptive summaries.

Given the limited sample size, an exploratory modeling approach was adopted for the multivariate regression analysis. All available demographic and clinical variables were entered simultaneously into the model using a forced-entry approach, given the exploratory nature of the study and the limited sample size. While this approach enables the identification of potential associations, it may also

increase the risk of overfitting and reduce statistical power. Future studies with larger samples should consider more targeted modeling strategies to enhance statistical robustness and interpretability.

An a priori sample size calculation was conducted using G*Power 3.1. Based on recommendations for a medium effect size ($f^2 = 0.15$), $\alpha = 0.05$, power = 0.80, and 9 predictor variables, the required minimum sample size for multivariate linear regression was 114 participants[31, 32]. However, only 36 valid responses were obtained, and this discrepancy should be interpreted in light of ethical, practical, and methodological constraints. Such limitations are not uncommon in regression-based health studies[32].

Several factors restricted further participant recruitment. First, under local ethical guidance for service evaluation projects, patients could only be contacted once after discharge, unless re-approached by their treating team. Second, mailing each questionnaire package cost approximately £1.55, making large-scale distribution financially infeasible without external funding. Finally, since patients tend to reach a functional plateau after elbow surgery, extending the follow-up window could increase heterogeneity and recall bias. These constraints reflect a considered compromise between methodological rigour, ethical responsibility, and logistical feasibility. Given the exploratory nature of the study and the small sample size, unadjusted regression coefficients were not reported. All variables were entered simultaneously into the model, and the coefficients presented are adjusted for the other covariates. This approach prioritises parsimony and minimises the risk of spurious findings from multiple univariable analyses.

2.6 Ethics Statement and Consent Procedure

This study was registered via the Nottingham University Hospitals NHS Trust audit platform and approved (Audit ID: 25-303C). All trauma registry records were anonymised before researcher access. Participation in the survey was voluntary, with return of the completed questionnaire considered implied informed consent under ethical guidance for low-risk anonymised studies.

3 Result

3.1 Overview of Analytical Cohorts

Data presentation in this study is structured around two distinct cohorts to ensure clarity: (1) the Initial Cohort, comprising all 128 eligible patients, is used to describe the overall distribution of injury mechanisms, fracture types, and surgical procedures within the studied population (Sections 3.2–3.4); and (2) the Responder Cohort, consisting of the 36 patients who returned valid questionnaires, forms the basis for all patient-reported outcome (PROM) analyses and investigations into influencing factors (Section 3.5 onwards).

3.2 Demographic Comparison Between Initial and Responder Cohorts

Baseline characteristics of the study cohorts are summarized in Table 1. The sex distribution did not differ significantly between responders and the initial cohort ($\chi^2(1) = 0.606$, $p = 0.436$). In contrast, a significant difference was observed in age distribution ($\chi^2(7) = 33.310$, $p < 0.001$). Responders were

disproportionately represented in the 51–70 year age groups, while response rates were notably low among younger patients aged 21–40.

Table 1. Comparison of demographic characteristics between the initial cohort, responders, and non-respondents (n = 128).

Characteristic	All patients (n=128)	Respondents (n=36)	Non-respondents (n = 92)	*p*-value
Sex, n (%)				0.436
Male	71(55.5%)	18(50%)	53(57.6%)	
Female	57(44.5%)	18(50%)	39(42.4%)	
Age group, n (%)				0.001
18-20	6(4.7%)	1(2.8%)	5(5.4%)	
21-30	24(18.8%)	1(2.8%)	23(25.0%)	
31-40	20(15.6%)	0(0.0%)	20(21.7%)	
41-50	13(10.2%)	3(8.3%)	10(10.9%)	
51-60	27(21.1%)	11(30.6%)	16(17.4%)	
61-70	19(14.8%)	12(33.3%)	7(7.6%)	
71-80	13(10.2%)	4(11.1%)	9(9.8%)	
81-85	6(4.7%)	4(11.1%)	2(2.2%)	

3.3 Distribution of Injury Mechanisms

The distribution of injury mechanisms for the initial cohort (n=128) is summarized in Figure 2. Falls from standing height (FSH) were the most common cause, accounting for 42.2% (n=54) of all fractures, followed by road traffic collisions (RTC, 23.4%, n=30) and falls from height (FH, 18.8%, n=24). When stratified by age (<50 vs. ≥51 years), a distinct pattern emerged (Figure 3). RTCs were more frequent in patients under 50, whereas FSH predominated in those aged 51 and above.

3.4 Distribution of Fracture Types

The distribution of fracture types within the initial cohort is illustrated in Table 2. Olecranon fractures were the most prevalent, constituting 63.3% (n=81) of cases, followed by Combined Elbow Injuries (17.2%, n=22), Distal Humerus Fractures (11.7%, n=15), and Radial Head Fractures (7.8%, n=10).

Table 2. Distribution of fracture types in the initial cohort (n=128).

Fracture Type	Number of Patients (n=128)	Percentage (%)
Olecranon fractures	81	63.3
Combined Elbow Injuries	22	17.2
Distal Humerus Fractures	15	11.7
Radial Head Fractures	10	7.8
Total	128	100

3.5 Types of Surgical Procedures

The types of surgical procedures performed are summarized in Table 3. Internal fixation (IF) was the most common procedure, used in 83.59% (n=107) of patients.

Table 3. Distribution of primary surgical procedures in the initial cohort (n=128)

Surgical Procedure	Number of Patients (n=128)	Percentage (%)
Internal Fixation	107	83.59
Arthroplasty	10	7.81
Soft Tissue Repair	6	4.69
Combined Reconstruction	4	3.13
Excision Procedure	1	0.78
Total	128	100

3.6 Characteristics and PROM Scores of the Responder Cohort

The primary patient-reported outcome measures for the 36 respondents are summarized in Table 4. Valid DASH scores were available for 34 participants (two exclusions: one with >3 missing items, one non-respondent to this section), yielding a median score of 10.30 (IQR 3.15–34.55; range 0.0–95.5). All 35 respondents who completed the EQ-5D-5L provided both an index value and an EQ-VAS score. The median EQ-5D-5L health utility index was 0.34 (IQR 0.10–0.60; range −0.08–0.97), and the median EQ-VAS score was 75.0 (IQR 60.0–90.0; range 10.0–100.0).

Table 4. Summary of DASH, EQ-5D-5L, and EQ-VAS Scores

	n	Median (IQR)	Range
DASH	34	10.30 (3.15–34.55)	0.0–95.5
EQ-5D-5L	35	0.34(0.10–0.60)	-0.08–0.97
EQ-VAS	35	75.0 (60.0–90.0)	10.0–100.0

3.7 Factors Associated with Functional Outcomes and Health-Related Quality of Life

3.7.1 Univariable Analyses

Initial exploration of associations between key demographic/clinical variables and the primary outcomes was conducted using non-parametric tests (Mann-Whitney U) and correlation analyses. As detailed in the Statistical Analysis section, the non-normal distribution of the primary outcomes warranted the use of non-parametric methods.

DASH Score: A Mann-Whitney U test revealed a statistically significant difference in DASH scores based on occupation type (U = 81.5, Z = −2.159, p = 0.031). Participants engaged in manual work had significantly lower DASH scores (median = 4.40, IQR 1.72–20.83) than those in non-manual work (median = 21.18, IQR 9.90–45.10), indicating better self-reported upper limb function among the former group (Table 5, Figure 4).

Table 5. Comparison of DASH Scores Between Manual and Non-Manual Occupation Groups (Mann–Whitney U Test) (n=34)

	n	Mean Rank	U	*p*-value
Non-manual occupation	18	20.97		
Manual occupation	16	13.59	81.5	0.031

EQ-VAS Score: Patients without comorbidities reported significantly higher EQ-VAS scores (median = 85.0, IQR 77.5–90.0) compared to those with comorbidities (median = 70.0, IQR 60.0–80.0) (U = 82.5, Z = −2.183, p = 0.029) (Table 6, Figure 5).

Table 6. Comparison of EQ-VAS Scores by Comorbidity Status (Mann–Whitney U Test)(n=35)

	n	Median (IQR)	U	*p*-value
No comorbidity	14	85.0 (25)		
With comorbidity	21	70.0 (30)	82.5	0.029

Correlations between PROMs: Spearman's rank correlation analysis indicated a moderate negative correlation between DASH and EQ-VAS scores (ρ = −0.631, p < 0.001). No significant correlation was observed between DASH and the EQ-5D-5L index score (ρ = −0.029, p = 0.871), or between the EQ-5D-5L index and EQ-VAS (ρ = 0.140, p = 0.429) (Table 7).

Table 7. Spearman’s Correlation Coefficients Between DASH, EQ-VAS, and EQ-5D-5L Scores

Variable Pair	Correlation Coefficient (r)	*p*-value	Sample Size (n)
DASH vs EQ-VAS	-0.631	<0.001	34
DASH vs EQ-5D-5L	-0.029	0.871	34
EQ-VAS vs EQ-5D-5L	0.140	0.429	35

3.7.2 Exploratory Multivariable Linear Regression

To investigate whether the associations identified in univariable analyses persisted after adjustment for potential confounders, exploratory multiple linear regression models were fitted. Although the primary outcomes were not normally distributed, linear regression is considered robust to moderate deviations from normality and was deemed appropriate for this exploratory analysis aiming to assess multiple covariates simultaneously. Given the limited sample size and the exploratory aim of these models, only adjusted coefficients are reported below.

DASH Score Model: The regression model for DASH score exhibited low explanatory power (adjusted $R^2 = -0.010$) and was not statistically significant overall ($F(9, 24) = 0.964$, $p = 0.493$). The association between manual occupation and lower DASH scores, which was significant in the univariable analysis, was attenuated to borderline significance after adjusting for age, sex, comorbidity status, fracture type, injury mechanism, and time since injury (B = −22.38, 95% CI: −45.68 to 0.92, $p = 0.059$) (Table 8). No other variables were significant predictors.

Table 8. Multiple Linear Regression Analysis for DASH Score (n=34)

	Coefficient (B)	95% Confidence Interval	*p*-value
Constant	8.844	-84.12–101.81	0.846
Age (years)	0.033	-0.93–0.99	0.944
Sex (Male vs. Female)	-7.113	-28.157–13.93	0.492
Occupation (Manual vs. Non-manual)	-22.381	-45.68–0.92	0.059
Time Since Injury(months)	1.117	-1.05–3.29	0.299
Comorbidity status	8.121	-17.19–33.43	0.514
Radial Head Fracture	13.297	-39.89–66.48	0.611
Olecranon Fracture	0.843	-33.31–34.99	0.960
Distal Humerus Fracture	17.378	-26.44–61.19	0.421
Mechanism of Injury	-1.576	-22.51–19.36	0.878

Note: Fracture type was included as a categorical variable using dummy coding, with patients with combined/complex fractures serving as the reference category. DASH score range: 0–100, where higher scores indicate worse upper limb function. Positive coefficients (B > 0) are associated with higher DASH scores (worse functional outcome), whereas negative coefficients (B < 0) are associated with lower DASH scores (better functional outcome).

EQ-VAS Score Model: The model for EQ-VAS explained a modest proportion of variance (R^2 = 0.391, adjusted R^2 = 0.171) but was not statistically significant overall ($F(9, 25) = 1.781$, $p = 0.123$). Within this model, male sex (B = 17.20, 95% CI: 0.79 to 33.61, $p = 0.041$) and a shorter time since injury (B = −1.85, 95% CI: −3.54 to −0.16, $p = 0.033$) emerged as significant independent predictors of a higher (better) EQ-VAS score (Table 9). A regression model for the EQ-5D-5L index score demonstrated poor fit (adjusted R^2 = 0.061) and revealed no significant predictors, therefore detailed results are not presented.

Table 9. Multiple Linear Regression Analysis for EQ-VAS Score (n=35)

	Coefficient (B)	95% Confidence Interval	*p*-value
Constant	116.859	46.23–187.49	0.002
Age	-0.329	-1.07 to 0.41	0.359
Sex (Male vs. Female)	17.201	0.79–33.61	0.041
Occupation (Manual vs. Non-manual)	6.618	-11.69–24.93	0.464
Time Since Injury(months)	-1.852	-3.54–-0.16	0.033
Comorbidity status	-17.838	-37.73–2.06	0.077
Radial Head Fracture	-21.962	-63.66–19.73	0.288
Olecranon Fracture	-6.939	-33.62–19.74	0.597
Distal Humerus Fracture	-10.831	-45.23–3.57	0.523
Mechanism of Injury	6.912	-9.53–23.36	0.395

Note: Fracture type was included as a categorical variable using dummy coding, with patients with combined/complex fractures serving as the reference category. EQ-VAS score range: 0–100, where higher scores indicate better self-perceived health status. Positive coefficients (B > 0) are associated with higher EQ-VAS scores (better perceived health), whereas negative coefficients (B < 0) are associated with lower EQ-VAS scores (worse perceived health).

3.7.3 Detailed Item-Level Analysis of PROMs

To identify specific areas of difficulty, the highest-scoring (most problematic) items on the DASH questionnaire are listed in Table 10 (see also Figure 6). Recreational activities involving the arm, feeling less capable, and carrying heavy objects (>5 kg) were the most frequently reported challenges.

Table 10. Top Five Highest-Scoring Items on the DASH Questionnaire(n=34)

Rank	Item No.	Questionnaire Item	Mean±SD
1	Q18	Recreational activities that involve arm, shoulder or hand.	2.56±1.48
2	Q30	Feel less capable, less confident or less useful because of arm, shoulder or hand.	2.53±1.38
3	Q11	Carry a heavy object (≥5 kg).	2.34±1.54
4	Q28	Stiffness in arm, shoulder or hand.	2.24±1.18
5	Q8	Garden or outdoor property work.	2.18±1.36

Among the five dimensions of the EQ-5D-5L, Pain/Discomfort was the most commonly reported problem, with only 37% (n=13) of respondents reporting no pain (Figure 7). The distribution of response levels across all five dimensions is detailed in Table 11.

Table 11. Distribution of Responses Across the Five Dimensions of the EQ-5D-5L（n=35）

	Level 1	Level 2	Level 3	Level 4	Level 5
Mobility	24(69%)	5(14%)	4(11%)	1(2.9%)	1(2.9%)
Self-Care	27(77%)	4(11%)	2(5.7%)	0(0%)	2(5.7%)
Usual Activities	22(63%)	4(11%)	6(17%)	2(5.7%)	1(2.9%)
Pain/Discomfort	13(37%)	15(43%)	5(14%)	1(2.9%)	1(2.9%)
Anxiety/Depression	18(51%)	8(23%)	7(20%)	2(5.7%)	0(0%)

Note: See note to Figure 7.

4 Discussion

4.1 Key Findings

This study systematically assessed upper limb function and HRQoL in patients recovering from elbow fracture surgery using the DASH and EQ-5D-5L instruments. Three key findings emerged. First, while median DASH scores indicated generally good functional recovery (10.3), significant heterogeneity existed, with high-demand activities posing persistent challenges. Second, and most strikingly, the median EQ-5D-5L index of 0.34 represented a severe deficit compared to UK population norms for comparable age groups, which are reported as 0.844 (men aged 55–64), 0.842 (men aged 65–74), 0.826 (women aged 55–64), and 0.822 (women aged 65–74)[33]. This gap of approximately 0.48 to 0.50 points on the utility scale underscores a profound long-term impact on overall health utility following an

elbow fracture. Third, occupational type and comorbidity status emerged as salient factors associated with functional and perceptual outcomes, respectively, though the former association was attenuated in multivariable analysis.

Notably, within the EQ-5D-5L instrument itself, a discrepancy was observed between the preference-based index and the self-rated EQ-VAS. While the index indicated a severe health utility deficit (median 0.34), the EQ-VAS suggested a more moderate self-perception of overall health (median 75.0). This highlights the distinction between a standardized, multi-attribute utility measure and a global, subjective health rating. Furthermore, regression analyses revealed different predictors for these two outcomes: time since injury and sex were associated with EQ-VAS but not with the EQ-5D-5L index. This suggests that global health perception (EQ-VAS) may be more sensitive to specific demographic and temporal factors, whereas the health utility index reflects a more stable, yet profoundly impacted, summary measure following trauma.

This finding is in contrast to most previous studies reporting poorer outcomes among manual workers. For example, a Swedish study on patients with upper limb trauma reported that those in manual occupations had approximately 1.8 times the risk of developing marked functional disability (Quick DASH > 40) compared with their non-manual counterparts, indicating poorer recovery among manual workers[34]. Similarly, Marom et al. observed a significant delay in return-to-work among manual laborers, indirectly reflecting the greater complexity of their rehabilitation process[35].

However, the DASH score is a subjective self-assessment tool that reflects not only objective functional capacity but also the individual's occupational context and personal expectations. Studies have shown that self-reported symptoms such as pain and activity limitation are closely associated with actual occupational exposure, indicating that manual workers may be more sensitive to even mild impairments, which could lead to elevated self-reported scores[36, 37]. Moreover, Hassoun et al. found a discrepancy between DASH scores and radiographic findings, suggesting that the DASH score more accurately captures patients' subjective experiences rather than objective clinical status[38].

Notably, while this association was significant in the univariable Mann-Whitney U test ($p = 0.031$), a cautious interpretation of our finding is warranted. In the multivariable analysis, the association between manual occupation and better DASH scores was attenuated to borderline significance ($p = 0.059$). Coupled with the limited sample size of this exploratory study, this suggests that the observed relationship may be sensitive to confounding or requires validation in a larger cohort. Therefore, it should be viewed as a preliminary signal that occupational context can influence self-reported recovery in complex ways, rather than as a definitive clinical conclusion.

Notably, some studies have also demonstrated that when rehabilitation programs are tailored to include job-specific tasks—such as grip strength enhancement or lifting simulations—manual workers can achieve meaningful improvements in functional outcomes[39]. Therefore, occupational attributes should not be viewed solely as negative prognostic indicators, but rather as key considerations in the design of

targeted interventions. Future research should integrate both subjective and objective functional metrics alongside occupational task analysis to establish context-aware rehabilitation frameworks.

EQ-5D-5L results indicated that pain/discomfort was the most commonly reported issue among participants, with 63% experiencing difficulties in this dimension. This finding aligns with prior studies that underscore the significance of pain in recovery. For instance, Donati et al. noted in a follow-up study of patients recovering from elbow fractures that persistent pain remains a prominent concern during the mid-phase of rehabilitation, constituting a key barrier to the restoration of quality of life[13].

This study also found that patients with comorbidities had significantly lower EQ-VAS scores than those without (p = 0.029), indicating reduced perceived HRQoL. Common conditions included hypertension, diabetes, osteoporosis, and arthritis. The observed reduction in perceived HRQoL among these patients is consistent with broader evidence linking such comorbidities to impaired bone healing, chronic pain, and poorer patient-reported outcomes after musculoskeletal injury[40, 41]. Thus, recovery management should incorporate comorbidity control alongside fracture treatment to improve both function and quality of life. Higher EQ-VAS scores in men and declining scores with longer post-injury time may reflect psychosocial influences—such as activity patterns, health perception, or rehabilitation adherence. Similar trends in musculoskeletal research suggest that demographic and temporal factors can affect self-reported HRQoL independently of objective function.

Although both DASH and EQ-5D-5L were used to assess upper limb function and HRQoL, no significant correlation was found (p > 0.05), suggesting that these outcomes may not be directly related in elbow fracture recovery. This likely reflects the different constructs measured: DASH focuses on upper limb function and daily activity limitations, while EQ-5D-5L captures broader aspects of quality of life, including pain, psychological well-being, and self-perceived health, which may not align with physical function.

The profound deficit in HRQoL observed in our cohort gains further significance when contextualized within the broader landscape of upper limb trauma research. The definitive Distal Radius Acute Fracture Fixation Trial (DRAFFT) concluded that for dorsally displaced distal radius fractures, there is no clinically relevant difference between surgical fixation methods in terms of HRQoL [42]. This pivotal finding shifts the focus away from technical superiority of one implant over another. Instead, our study illuminates a more fundamental and severe issue: irrespective of surgical technique, patients recovering from elbow fractures sustain a catastrophic loss in overall health utility, with a median index (0.34) representing a deficit of approximately 0.50 points compared to population norms. Therefore, while trials like DRAFFT resolve questions about how to fix a fracture, our data highlight the imperative to address the severe consequence of the injury itself on a patient's quality of life. This necessity for a multidimensional assessment is further supported by psychometric evidence.

A systematic review found that construct validity between PROMs such as DASH, EQ-5D, and VAS is generally moderate to low in upper limb trauma, indicating that they capture different health dimensions rather than a shared construct[43]. In our study, the low median DASH score (10.3) and high EQ-5D-5L

scores suggest a possible ‘ceiling effect’, where these instruments cannot distinguish well among patients with good recovery, thereby weakening their statistical association[44-46].

Moreover, psychosocial factors—such as fear of movement, anxiety, and perceived social support—can substantially influence PROM scores. The same review by Jayakumar et al. included longitudinal data from elbow fracture patients, showing that at 6–9 months post-operation, psychological expectations and social adjustment predicted DASH and EQ-5D outcomes more strongly than anatomical status[43]. Thus, relying on single measure risks oversimplifying patients’ recovery experiences. The absence of strong correlation between DASH and EQ-5D-5L instead highlights their complementary roles, with each capturing distinct yet important aspects of recovery.

4.2 Limitations and Strengths

Despite efforts to adhere to rigorous scientific standards in study design, instrument selection, and data analysis, several limitations should be acknowledged when interpreting the findings. First, the sample size was relatively small, with only 36 completed questionnaires returned, yielding a response rate of 28.1%, far below the target sample size (n = 114). This limited power may have increased the risk of Type II errors and reduced the stability of multivariable estimates.

Second, there was a significant age distribution discrepancy between respondents and the overall eligible population ($p < 0.05$). The returned questionnaires were predominantly from patients aged 51–70, while response rates were markedly lower among younger patients (aged 21–40). Moreover, as the data were collected from a single centre, the resulting selection bias may compromise the representativeness of the sample, as institutional protocols, rehabilitation resources, and patient demographics may vary considerably across different healthcare settings.

Third, the postoperative period among included patients ranged from 11 to 36 months, which may have introduced confounding effects of rehabilitation stage on recovery outcomes and affected the comparability of cross-sectional data. Additionally, both DASH and EQ-5D-5L are subjective, self-reported measures. While they provide valuable insight from the patient’s perspective, the absence of objective functional indicators may limit the interpretative depth, and such measures are also susceptible to recall bias and social desirability bias. Consistent with the cautious interpretation required for the occupational association discussed above, the regression model for DASH yielded an adjusted R^2 value close to 0, indicating a limited predictive capability and suggesting the need for more comprehensive variable inclusion and larger sample sizes in future studies. Lastly, the study did not incorporate key psychosocial confounding variables, such as fear of pain, anxiety, or social support, which have been shown to significantly influence PROM scores.

Nevertheless, this study has notable strengths. Using both DASH and EQ-5D-5L provided a complementary framework covering upper limb function and HRQoL, offering a holistic perspective on recovery. Contextual factors such as occupation and comorbidities were also examined, informing

individualised intervention strategies. Finally, as an empirical PROM-based exploration, the study offers a foundation for future patient-centred assessment frameworks.

4.3 Relevance to Clinical Practice and Future Directions

This study offers several implications for rehabilitation practice. First, functional recovery and subjective health perceptions are shaped by individual and social differences, underscoring the need for tailored, context-sensitive plans. Patients with chronic comorbidities may benefit from multidisciplinary approaches integrating disease management, while persistent postoperative pain warrants multimodal strategies combining pharmacologic, physical, and psychological interventions to protect long-term quality of life.

Second, the absence of significant correlation between DASH and EQ-5D-5L scores shows that function and quality of life are not always aligned, highlighting the value of using complementary PROMs. Future frameworks should integrate tools such as the Numeric Pain Rating Scale (NPRS), Hospital Anxiety and Depression Scale (HADS), and work ability assessments, alongside objective measures like range of motion and grip strength, to address physiological, psychological, and social dimensions.

Finally, given the impact of psychosocial factors, rehabilitation pathways should incorporate emotional screening and social support, shifting from purely functional models toward patient-centered care. Future longitudinal and interventional studies targeting subgroups (e.g., older adults, patients with comorbidities) could enhance precision and scalability. Overall, recovery models should evolve from standardized protocols to personalized strategies that integrate patient perceptions, occupational needs, and psychological adaptation.

Conclusion

This study highlights the influence of individual factors on functional recovery and health-related quality of life after elbow fractures. The findings suggest that rehabilitation assessment should adopt a patient-centered, multidimensional approach that integrates physical function, psychosocial context, and occupational demands. Future studies are encouraged to incorporate objective assessments and psychosocial determinants to enhance the robustness of recovery evaluation.

Declarations

Ethics approval

This study was registered and approved as a service evaluation project by the Nottingham University Hospitals NHS Trust audit platform (Audit ID: 25-303C). It was conducted in accordance with the Declaration of Helsinki.

Consent to participate

As this was a service evaluation project, formal informed consent was not required. All data were anonymized prior to analysis.

Consent for publication

Not applicable. No individual person's data are presented in this manuscript.

Data Availability

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

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Competing Interest declaration

The authors have no competing interests to declare.

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Figures

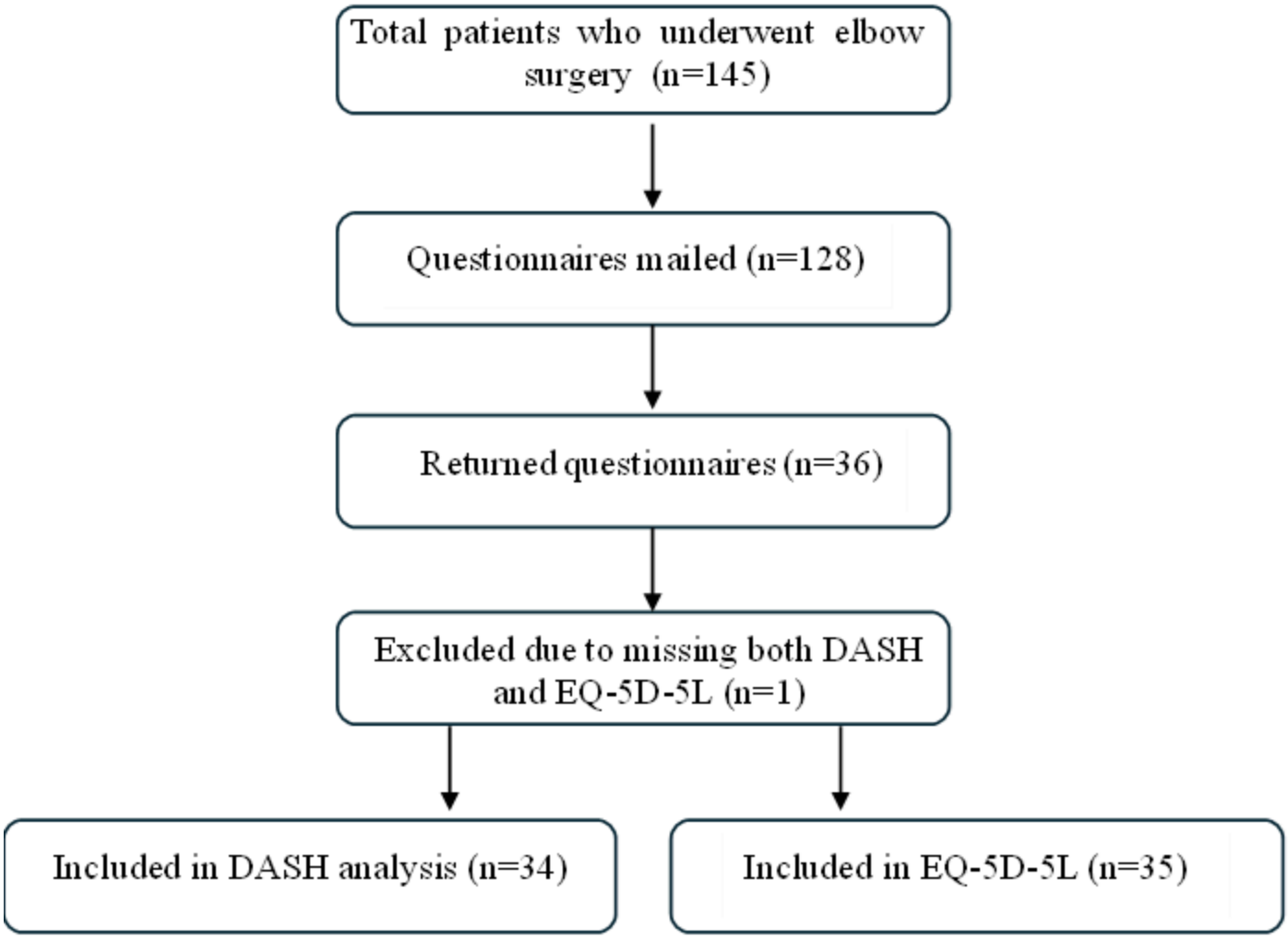


Figure 1

Flow chart of questionnaire distribution and inclusion in outcome analysis.

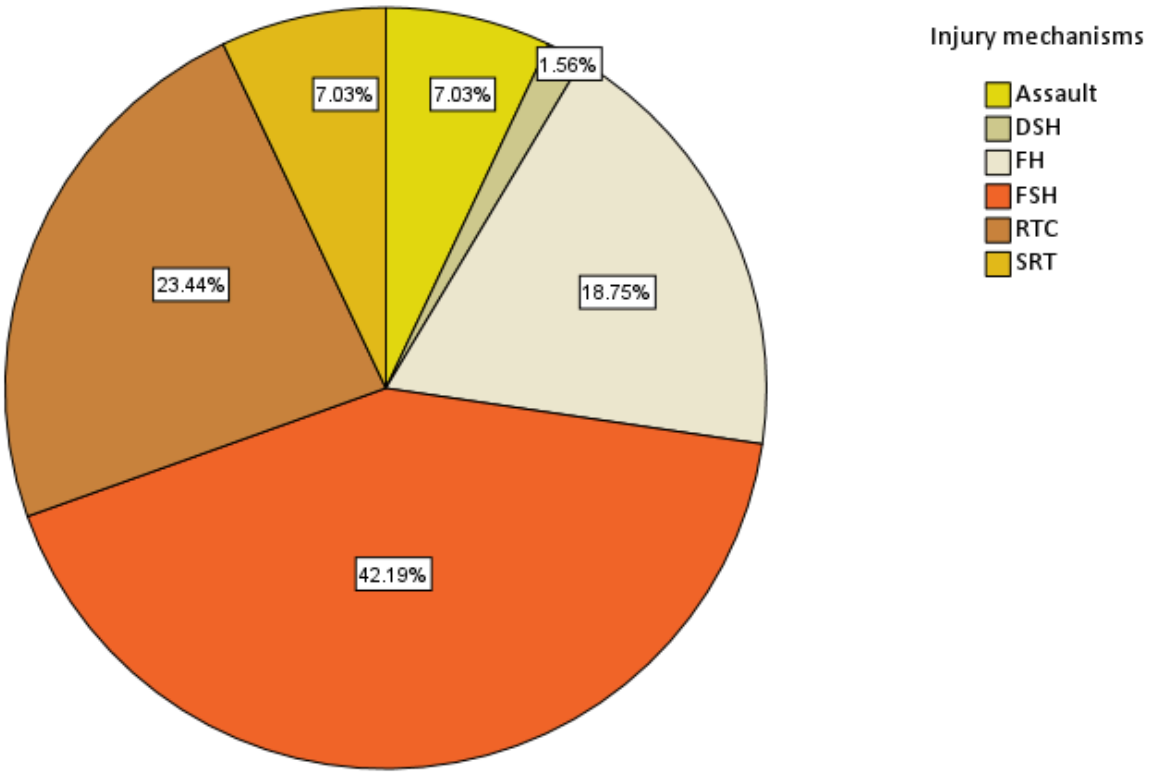


Figure 2

Distribution of Injury Mechanisms Among Patients with Elbow Fractures

Note: FSH = Fall from standing height; RTC = Road traffic collision; FH = Fall from height; SRT = Sports or recreational activities; DSH = Deliberate self-harm.

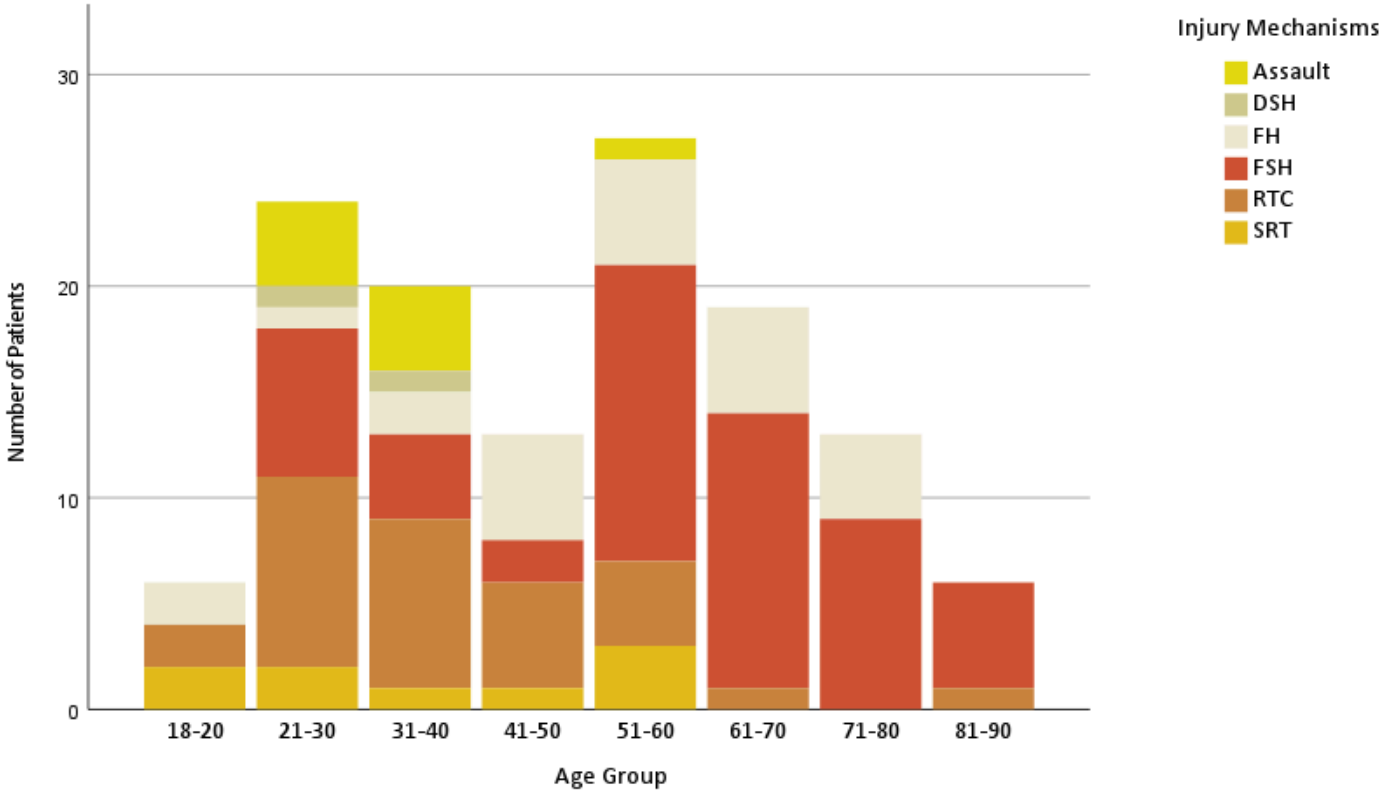


Figure 3

Distribution of Injury Mechanisms by Age Groups

Note. See note to Table 2.

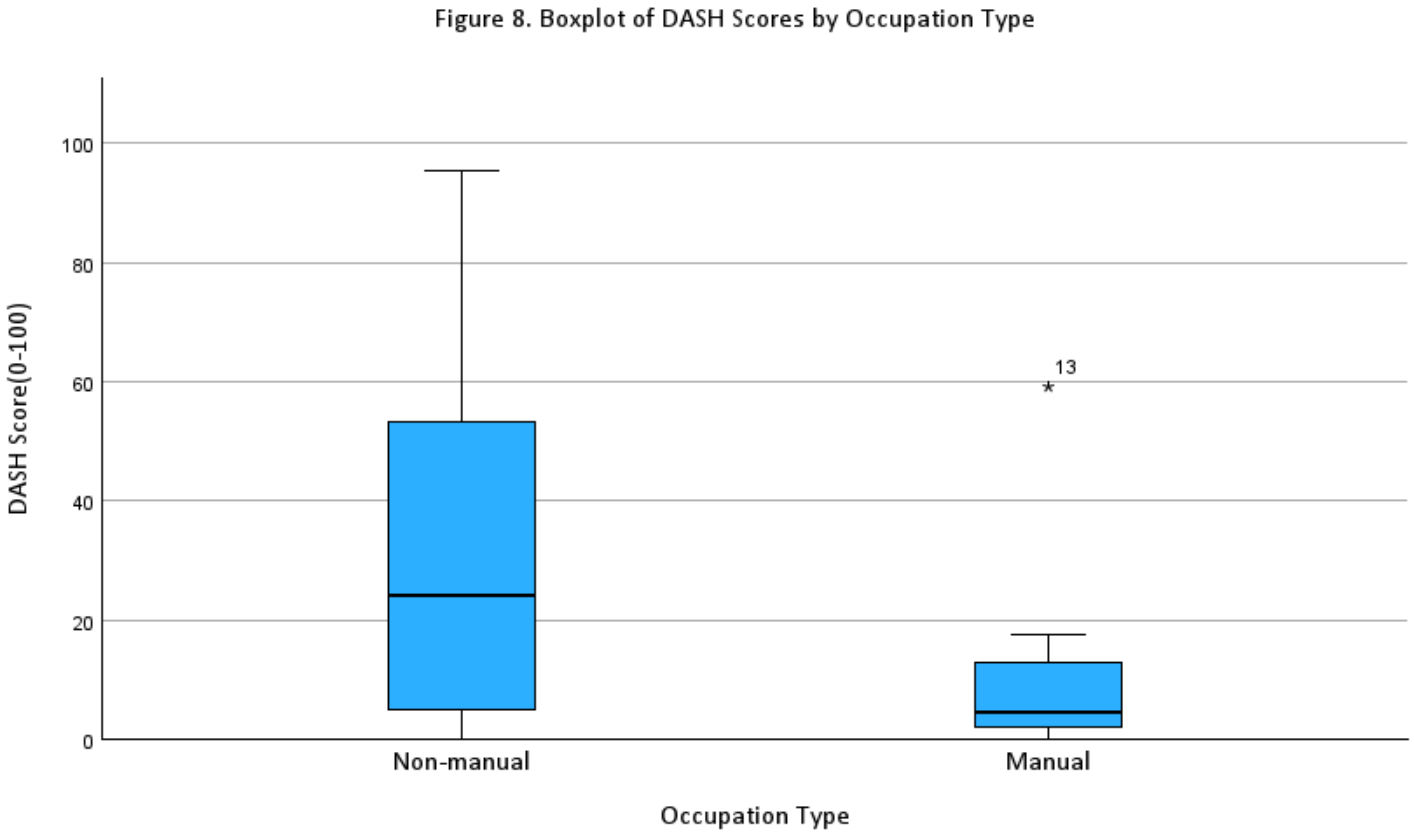


Figure 4

Boxplot of DASH Scores by Occupation Type

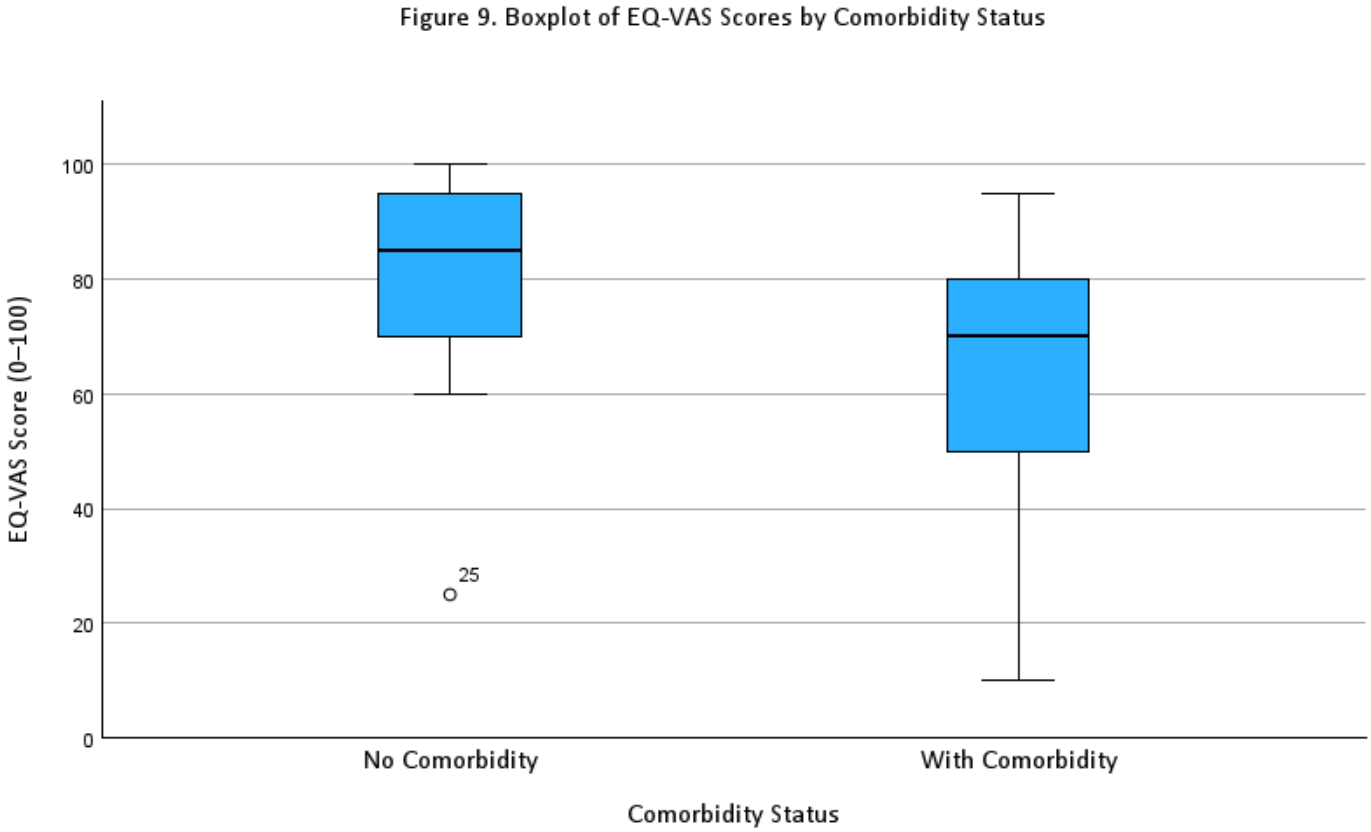


Figure 5

Boxplot of EQ-VAS Scores by Comorbidity Status

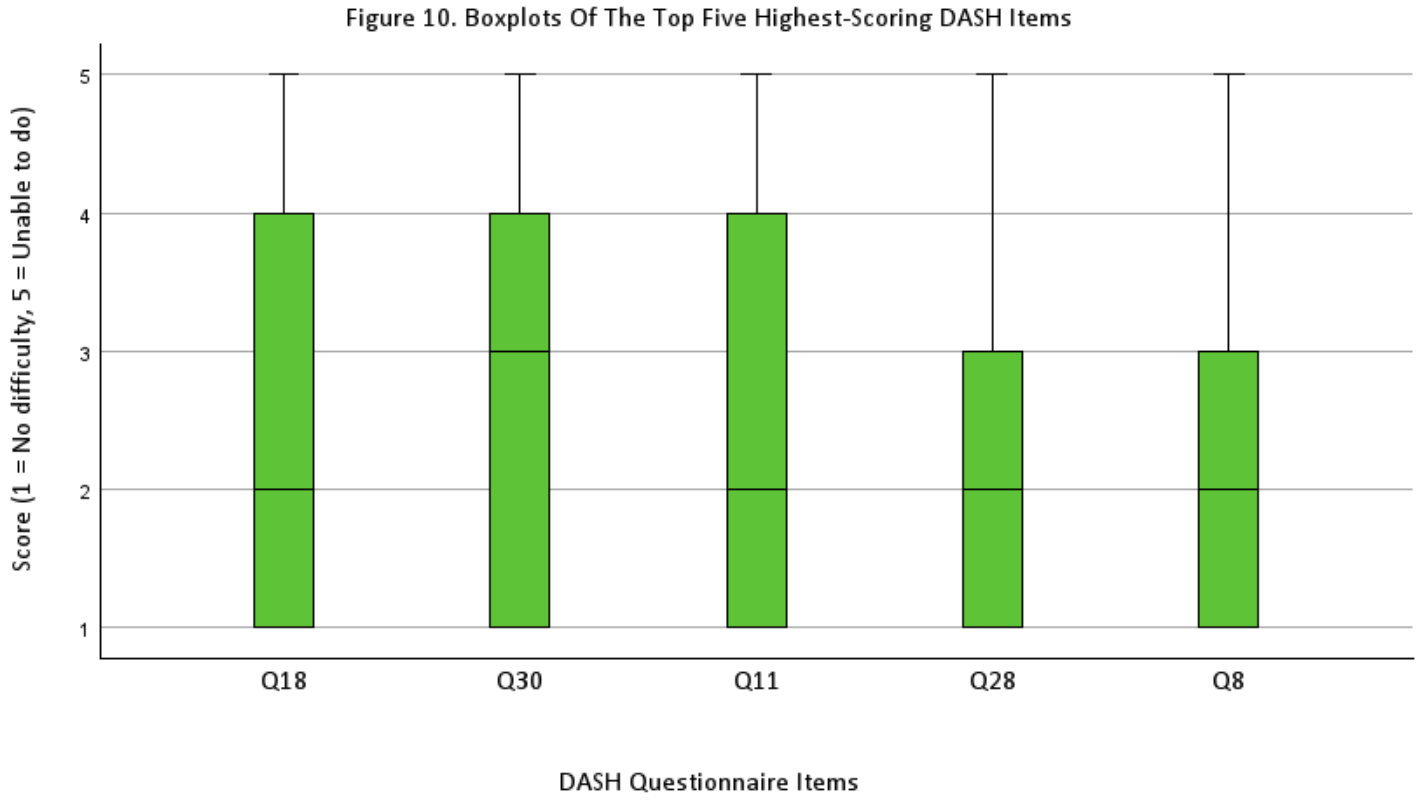


Figure 6

Boxplots of the Top Five Highest-Scoring DASH Items

Note. The specific content and description of each abbreviated item (e.g., Q8, Q11) are provided in Table 10. Scores represent perceived difficulty, ranging from 1 (no difficulty) to 5 (unable to do). Higher bars indicate greater self-reported disability for that specific task.

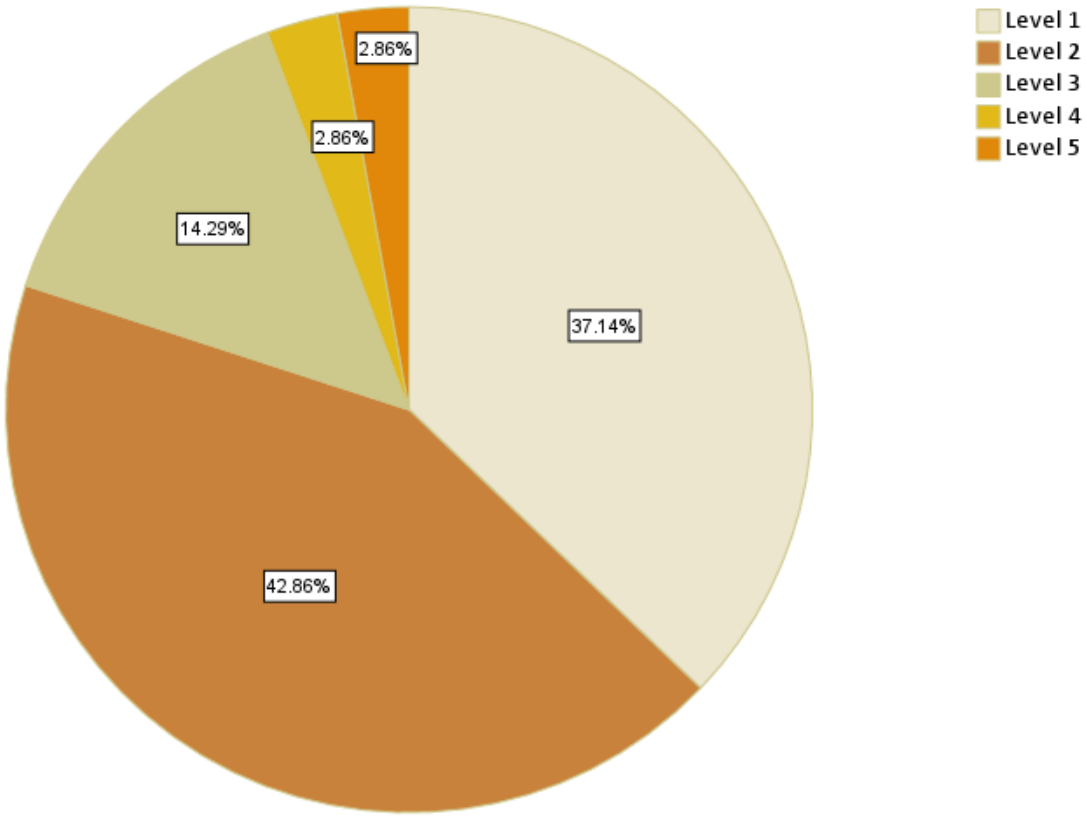


Figure 7

Proportion of EQ-5D-5L Pain/Discomfort Levels among Patients

Note: Levels indicate severity: 1 (no problems), 2 (slight problems), 3 (moderate problems), 4 (severe problems), and 5 (extreme problems/unable to perform).