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Systematic Review

What Factors Are Associated With Disability After Upper Extremity Injuries? A Systematic Review

Prakash Jayakumar MBBS, BSc (Hons), MRCS (Eng), DPhil, Celeste L. Overbeek MD, Sarah Lamb DPhil, Mark Williams DPhil, Christopher Funes MS, Stephen Gwilym FRCS(Orth), PhD, David Ring MD, PhD, Ana-Maria Vranceanu PhD

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Abstract

Background Psychosocial factors are key determinants of health after upper extremity injuries. However, a systematic review is needed to understand which psychosocial factors are most consistently associated with disability and how the language, conceptualization, and types of measures used to assess disability impact these associations in upper extremity injuries.

Questions/purposes (1) What factors are most consistently associated with disability after upper extremity injuries in adults? (2) What are the trends in types of

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This work was performed at The Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, Oxford, UK.

P. Jayakumar, S. Lamb, S. Gwilym, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Medicine, University of Oxford, Nuffield Orthopaedic Centre, Oxford, UK

C. L. Overbeek, Department of Orthopedic Surgery, Leiden University Medical Center, Leiden, The Netherlands

M. Williams, Department of Sport and Health Sciences, Oxford Brookes University, Oxford, UK

C. Funes, Department of Psychiatry (Behavioral Medicine Service), Boston, MA, USA

D. Ring, The University of Texas at Austin, Department of Surgery and Perioperative Care, Dell Medical School, Austin, TX, USA

A.-M. Vranceanu, Massachusetts General Hospital and Harvard Medical School, Behavioral Medicine Program, Department of Psychiatry, Boston, MA, USA

P. Jayakumar (✉), Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, Nuffield Orthopaedic Centre, Windmill Road, Headington, Oxford, OX3 7LD, UK, email: pjx007@gmail.com

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outcome measures and conceptualization of disability in patients' upper extremity injuries?

Methods We searched multiple electronic databases (PubMED, OVIDSP, PsycInfo, Google Scholar, ISI Web of Science) between January 1, 1996, and December 31, 2016, using terms related to the "upper extremity", "outcome measurement", and "impairment, psychological, social or symptomatic" variables. We included all studies involving adult patients with any musculoskeletal injury and excluded those that did not use patient-reported outcome measures. We identified and screened 9339 studies. Of these, we retained 41 studies that involved conditions ranging from fractures to soft tissue injuries in various regions of the arm. We conducted quality assessment using a 10-item validated checklist and a five-tier strength of evidence assessment. We used the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) criteria and registered the review before performing our search (PROSPERO: CRD42017054048). None of the authors received any funding to perform this work.

Results Disability after upper extremity injury was most consistently associated with depression (21 cohorts), catastrophic thinking (13 cohorts), anxiety (11 cohorts), pain self-efficacy (eight cohorts), and pain interference (seven cohorts). Social and demographic factors were also associated with disability. Measures of impairment such as ROM and injury severity were least associated with disability. There has been a gradual increase in use of region or condition-specific patient-reported outcome measures and measures of psychological, social, and symptomatic factors over a period since the introduction of the World Health Organization (WHO) International Classification of Functioning, Disability and Health (ICF) around 2000. Approximately 17% of studies (n = 454 of 2628) had instances of unclear, conflicting, or inappropriate terminology and 11% of studies (n = 257 of 2628) involved misrepresentations of outcome measures related to disability.

Conclusions Psychologic and social factors are most consistently associated with disability than factors related to impairment. Further research involving the assessment of depression, anxiety, and coping strategies in cohorts with specific injuries may support decision-making regarding the provision of emotional support and psychologic therapies during recovery. Using the WHO ICF framework to conceptualize disability is key in increasing strength of evidence and allowing accurate comparisons of research in this field.

Level of Evidence Level IV, therapeutic study.

Introduction

Understanding disability is fundamental in evaluating the outcomes of interventions after musculoskeletal injuries. The World Health Organization (WHO) International Classification of Functioning, Disability and Health (ICF) defines disability as a multidimensional construct involving a dynamic interaction between body functions and structures, activity limitations and participation restrictions, and environmental and personal factors associated with the relevant health condition (Fig. 1 A-B) [30, 53, 57]. Musculoskeletal injuries are often associated with substantial disability, affecting an individual's quality of life (QoL) [4, 13, 27, 45]. Orthopaedic trauma to the upper extremity demonstrates greater disability and reduced health-related QoL indices compared with other body regions [13, 14]. The inability to feed, clean, and clothe, particularly when a dominant arm is involved, can be debilitating.

There is growing recognition that the magnitude of disability correlates more with the subjective, psychosocial aspects of illness and pain (such as emotional distress and coping strategies) than objective measures of impairment and pathophysiology [17, 31, 33, 36, 54]. However, it is unclear which factors are most consistently associated with disability in orthopaedic trauma patients and what the strengths of these associations are. Furthermore, there is variability in the outcome measures used to assess disability, the manner in which the construct of disability is conceptualized, and the language used when defining the construct.

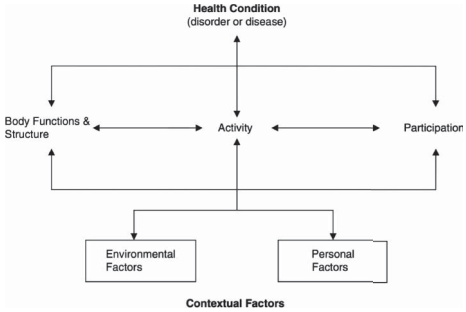
More than three decades since the introduction of the WHO ICF framework, there is still a level of misrepresentation and interchangeable use of terms related to disability and function despite the definitions being set out in the accompanying WHO manual [57]. The translation of research findings into the alleviation of posttraumatic disability requires a comprehensive summary of the factors associated with disability itself alongside clear and consistent language and conceptualization of the construct of disability.

We therefore performed a systematic review to answer the following questions: (1) What factors are most consistently associated with disability after upper extremity injuries in adults? (2) What are the trends in types of outcome measures used to represent disability and conceptualization of disability in patients with upper extremity injuries?

Materials and Methods

Search Strategy and Criteria

We used PubMED, OVIDSP, and PsycInfo electronic databases to identify all published studies from January 1, 1996, until December 31, 2016. We enlisted a librarian to determine a list of search terms and revised it as a



Definitions (Adapted from the full WHO report) (57)

ICF Component		Definition
Functioning		A term encompassing body functions, body structures, activities and participation, denoting the positive aspects of the interaction between an individual (with a health condition) and that individual's contextual factors (environmental and personal factors).
Disability		A term encompassing impairments, activity limitations and participation restrictions, denoting the negative aspects of the interaction between an individual (with a health condition) and that individual's contextual factors (environmental and personal factors).
Health condition		Diseases, disorders, injury and or trauma ageing and congenital anomaly
Level of Human Functioning (a) and dysfunction (b)		
I Body or body parts	a. Body functions and structures - Body functions - Body structure	Physiological functions of body systems (including physiological functions) Anatomical parts of the body e.g. organs, limbs and their components
	b. Impairment	Problems in body function or structure resulting in significant deviation or loss
II Whole person	a. Activities*	Execution of task or action by an individual
	b. Activity limitation	Difficulties an individual may have in executing activities
III Whole person in complete environment	a. Participation*	Involvement in a life situation
	b. Participation restriction	Problems an individual may experience in involvement in life situations
Contextual Factors		
	Environmental †	Aspects of physical, social and attitudinal environment in which people live and conduct their lives. These are either barriers or facilitators of a person's functioning
	Personal ‡	Features of the individual not part of health condition or health states that influence how disability is experienced by the individual

A

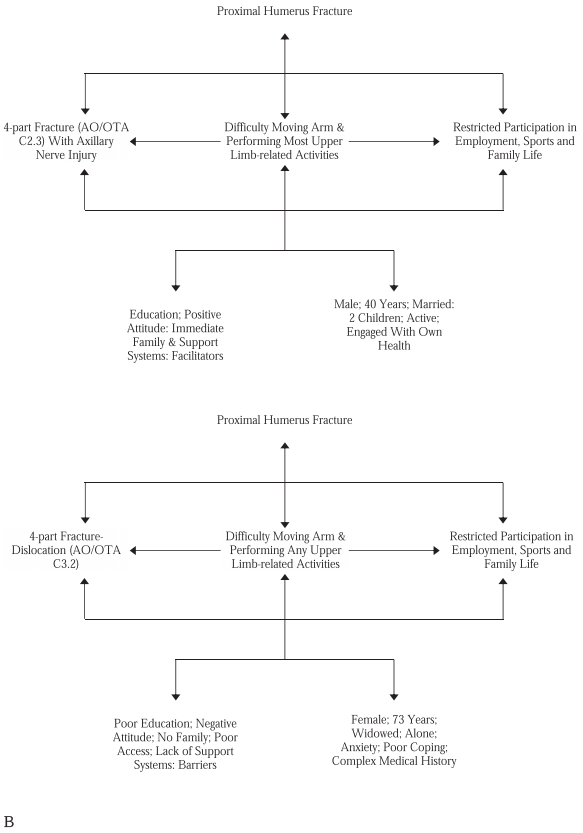


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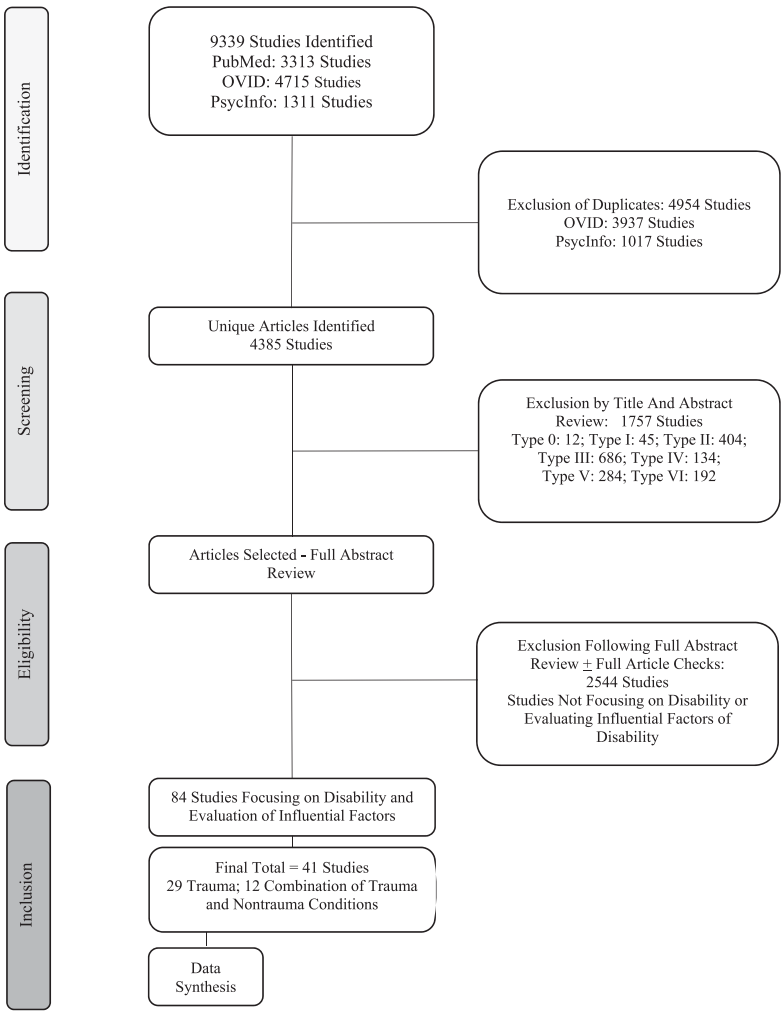
Fig. 1 A-B (**A**) A schematic is shown of the WHO ICF framework including ICF components and their definitions. *The activity and participation domains are organized into subdomains including: Learning and applying knowledge; General tasks and demands; Communication; Mobility; Self-care; Domestic life; Interpersonal international and relationships; Major life areas; Community, social and civic life. †The environmental domain is organized into subdomains including: Products and technology; Natural environment and human made changes to environment; Support and relationships; Attitudes; Services; Systems; Policies. ‡The personal domain is organized into subdomains including: Sex; Age; Race; Lifestyle habits; Coping styles; Social backgrounds; Education; Overall behavior patterns; Psychological assets. Adapted from: World Health Organization (Geneva) 2013. World Health Organization. How to use the ICF: A Practical Manual for Using the International Classification of Functioning. Available at: http://www.who.int/classifications/icf/en/. Accessed October 11, 2017. (**B**) Examples of the WHO ICF framework that was adapted to two different types of individual with a proximal humerus fracture. The examples include some features within each domain and are not intended to represent a complete overview of all subdomains. The direction of the arrows may differ depending on specific situations. Bidirectional arrows represent a two-way influence of one domain (or subdomain) on another.

multidisciplinary team. We combined terms related to "upper extremity", "outcome measurement", and "impairment, psychological, social and symptomatic variables" with the operator AND (Appendix, Supplemental Digital Content 1). The same search was used with additional electronic sources (Google Scholar, ISI Web of Science). No restrictions were set in the search fields and terms were identified in the title and/or abstract without limits. The review adheres to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) criteria [34] and the protocol is registered on the PROSPERO system (No. CRD42017054048).

All studies (Level I to Level IV) involving adult patients experiencing any musculoskeletal upper extremity injury condition for which they received operative and/or nonoperative interventions were eligible. Comparators were the outcome measures themselves and all outcomes were categorized into those assessing disability, impairment, psychologic, social, symptomatic, demographic, and other factors (Fig. 1 A-B). We followed strict identification and screening selection criteria (Fig. 2 A-B). We included only original research studies containing at least one patient-reported outcome measure (PROM) that could be equated to disability. We excluded studies focusing on clinometric features alone (eg, ROM, pathoanatomic or radiologic classification, clinical examination tests), single health components (eg, pain, depression, return to activity), and health behavior scales. Four



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Category	Exclusion Criteria	Exclusion Type
Participant	Study is not available in English; is an animal study; has no available abstract	Type 0
	Pediatric or adolescent patients	Type I
	Study involving nonmusculoskeletal upper extremity conditions, eg, neuromuscular, vascular	Type II
	Study not involving upper extremity condition or group of conditions	Type III
Intervention Comparator Outcome	Study involving only objective, pathoanatomical, clinical, process-level metrics, eg, ROM, radiographic classification, laboratory data, operative blood loss, length of stay, complications (basic science, biomedical, pure clinical) and/or no patient-reported outcome measures	Type IV
	Study involving development and/or psychometric evaluation of patient-reported outcome measure only	Type V
Study	Study is a technical report; protocol; case report; commentary; normative data (reference range) investigation; erratum; healthcare management; health economic evaluation	Type VI

B

Fig. 2 A-B (**A**) A flowchart demonstrates the number of articles selected during the stages of identification, screening, eligibility, and inclusion following a search period from January 1, 1996, to December 31, 2016. (**B**) Screening and exclusion criteria are shown.

investigators (PJ, A-MV, SG, CLO) performed identification and screening of titles and abstracts and two investigators (PJ, A-MV) conducted eligibility assessment. This phase entailed a closer inspection of abstracts and full-text review if there was any ambiguity in the abstract prose. The final set of full texts for inclusion was acquired and independently reviewed (PJ, A-MV, CF). Assessment for inclusion was performed together through discussion. We achieved a high level of consistency during the eligibility assessment and inclusion process, and consensus discussions were not required.

Quality assessment was conducted independently by three reviewers (PJ, A-MV, CF) using a 10-item checklist related to demographics, data collection, diagnosis, control group, participation/response rate, differences between responders and nonresponders, outcome measures, statistics, consent, and participant selection [23, 52]. This was a modified, population-specific version of established criteria used in previous systematic reviews of prognostic factors for patients with musculoskeletal disorders [23, 52]. The 10 items each had yes (+) and no (-) options, and we awarded a point (+) if there was sufficient information and no likelihood of potential bias. We calculated a quality score by counting all positively rated items (maximum score 10) and converted to a percentage total. An arbitrary classification was defined a priori as low (< 50%), moderate (50%-70%), and high quality (> 70%). Studies scoring > 50% were included in the strength of evidence evaluation. It was planned that any disagreements would be dealt with by reaching consensus with two additional authors (SG, MW) as required. However, a high level of consistency in agreement was present during quality assessment, and consensus discussions were not required.

We independently extracted data and recorded information using an electronic database (Microsoft Excel Version 15.32; Microsoft Inc, Redmond, WA, USA). A definition of variables was used as a reference throughout the review process (Appendix, Supplemental Digital Content 2). Extracted information included the official publication date, level of evidence, study design, study population, trauma region, and outcome measures, scales, and metrics pertaining to the domains assessed (Table 1). The key disability-focused findings and clinical and/or research sequelae were recorded (Appendix, Supplemental Digital Content 3). The next stage involved assimilating key statistical data pertaining to factors associated with disability from the full publication including any linked supplementary files. We reported study populations involving traumatic and nontraumatic conditions with aggregated data on the combined cohort as such unless there were specific data on the relevant subpopulation with a trauma problem. Further documentation of key influential factors was performed, charting the outcome measure(s) used, relevant statistics, and clinical grading if available. Finally, we performed a distribution analysis of the total study set that cleared the screening phase.

Selection of Studies

The database search provided a total of 9339 citations and after adjusting for duplicates, 4385 remained. Of these, 1757 were excluded by criteria after title and abstract screening and a further assessment of eligibility through closer abstract and full-text review excluded 2544 articles. This resulted in 84 studies involving disability and associated factors related to any orthopaedic condition. Of these, 41 studies solely involved trauma conditions (n = 29 of 41 [71%]) or a combined cohort of trauma and nontrauma conditions (n = 12 of 41 [29%]) (Fig. 2).

Study Characteristics

Definition of Study Designs, Diagnoses, and Outcome Measures

Most studies were cross-sectional (n = 25 of 41 [61%]) with highly variable levels of evidence (Level I, n = 12 of 41 [29%]; Level II, n = 10 of 41 [24%]; Level III, n = five of 41 [12%]; Level IV, n = 14 of 41 [34%]) (Table 1). Cohort sizes ranged from five [42] to 839 [35]. "Wrist and hand" trauma was most frequently investigated (n = 21 of 41 [51%]) followed by injuries involving more than one upper limb region (n = 16 of 41 [39%]) and single studies involving each of the remaining areas (n = four of 41 [10%]; shoulder, humerus, elbow, and forearm). The most frequently used PROM for disability was the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) (n = 17 of 41 [41%]) followed by the DASH (n = 16 of 41 [39%]) (Fig. 3). Participants included adults with a range of upper extremity conditions including injuries that ranged from soft tissue injuries to dislocations, subluxations, and fractures involving various regions of the arm treated with nonoperative and operative interventions.

Quality Assessment

Of the 41 studies, 15% (n = 6) of studies had moderate quality and 85% (n = 35) had high quality (Table 2). All studies met the threshold total score of > 50% and were thus included in the subsequent strength of evidence evaluation.

Table 1. Study characteristics, PRO measures of disability, variables associated with disability, and key statistical data

Study	Level of evidence	Design	Number	Trauma region	Disability measure	Patient characteristics	Impairment variables
Bear-Lehman and Poole, 2011 [2]	II	Evaluation at 7.5 months postinjury	24	Arm	QuickDASH		
Bekkers et al., 2014 [3]	IV	Evaluation (time point nos)	105	Wrist/hand	QuickDASH		
Bot et al., 2011 [7]	IV	Evaluation at mean 21 years postinjury	71	Forearm	DASH	X	
						X	
							X
							X
							X
							X
							X
							X
Bot et al., 2012 [8]	II	Prospective longitudinal evaluation at preoperatively and 3 months postsurgery	63	Wrist/hand	DASH		X
							X
					DASH		**X**
Bot et al., 2014 [5]	I	Evaluation at mean 48 days postinjury	82	Wrist/hand	QuickDASH	X	
						X	
Bot et al., 2014 [6]	I	Prospective longitudinal evaluation at mean 9 days and 33 days postinjury	70	Wrist/hand	QuickDASH	X	
						X	
						X	
Cederlund et al., 2010 [9]	I	Prospective longitudinal evaluation at 3 6 and 12 months postinjury	45	Wrist/hand	DASH		
					EQ-5D VAS		
					SF-36 PCS		
Chan et al., 2009 [10]	II	Evaluation at point of admission	57	Wrist/hand	DASH	X	
Constand et al., 2014 [11]	I	Prospective longitudinal evaluation at baseline (less than 10 days) and 3 months postinjury	129	Wrist/hand	PRWE (baseline)	**X**	
					PRWE (F/U)	**X**	
Das De et al., 2013 [12]	II	Evaluation (time point nos)	319	Wrist/hand	DASH	**X**	

Table 1. continued

Study	Level of evidence	Design	Number	Trauma region	Disability measure	Patient characteristics	Impairment variables
							X
Dogu et al., 2014 [15]	I	Prospective longitudinal evaluation at < 3 months and 6-9 months postsurgery	54	Wrist/hand	DASH (acute)		
					DASH (late)		
Döring et al., 2014 [16]	1	Evaluation (time point nos)	84	Wrist/hand	QuickDASH	X	
							X
					PROMIS UE PF	X	
							X
Farzad et al., 2015 [17]	III	Evaluation at mean 11 months postinjury	107	Wrist/hand	DASH	**X**	
							X
					MHQ	**X**	
							X
Golkari et al., 2015 [18]	I	Prospective longitudinal evaluation at mean 5 days and mean 36 days postinjury	69	Arm	No relevant analysis of predictors of disability		
Gong et al., 2011 [19]	I	Prospective longitudinal evaluation at baseline (week 0) 2 6 12 and 24 weeks postinjury	50	Wrist/hand	DASH (week 6)		
					DASH (week 12)		
					DASH (week 24)		
Gruber et al., 2014 [20]	II	Prospective longitudinal evaluation at baseline (first presentation) and 1 to 2 months after enrollment	112	Arm	QuickDASH (enrolment)	X	
					QuickDASH F/U	**X**	
						X	
						X	
Hageman et al., 2014 [21]	II	Evaluation (time point nos)	84	Arm	QuickDASH		
Helmerhorst et al., 2014 [22]	III	Evaluation at 1 to 2 months postsurgery	145	Arm	SMFA		
Janssen et al., 2015 [24]	IV	Evaluation at (median) 6 months	139	Arm	QuickDASH	X	
					PROMIS PF	**X**	
Jayakumar et al., 2015 [25]	IV	Evaluation (time point nos)	98	Arm	PROMIS PF	**X**	

Table 1. continued

Study	Level of evidence	Design	Number	Trauma region	Disability measure	Patient characteristics	Impairment variables
Keogh et al., 2010 [28]	IV	Evaluation at mean 11 days postinjury	87	Wrist/hand	PRWE	**X**	
							X
Kortlever and Janssen, 2015 [29]	IV	Evaluation at baseline (before physician review)	134	Arm	QuickDASH		
Mayland et al., 2017 [32]	IV	Evaluation at < 3 months since injury	84	Arm	QuickDASH		
Niekel et al., 2009 [35]	III	Retrospective evaluation	839	Arm	DASH	**X**	
					DASH		
					QuickDASH	**X**	
						X	
					QuickDASH		
Nota et al., 2016 [37]	I	Evaluation at time point nos	193	Arm	QuickDASH	**X**	
						X	
							X
							X
Novak et al., 2010 [38]	IV	Evaluation of injuries 0.5 to 15 years prior with minimum 6 months F/U	124	Arm	DASH		X
Novak et al., 2011 [39]	II	Evaluation of injuries from 0.5 to 15 years prior with minimum 6 months F/U	158	Arm	DASH	**X**	
						X	
						X	
							X
Novak et al., 2012 [40]	IV	Evaluation at minimum 6 months postinjury	61	Shoulder	DASH		
Peters et al., 2016 [41]	IV	Evaluation (time point nos)	111	Arm	PROMIS UE PF	X	
							X
Prugh et al., 2012 [42]	IIIb	Prospective longitudinal evaluation at baseline and 4 weeks	5	Elbow	QuickDASH (initial)		
Richards et al., 2011 [43]	IV	Evaluation of injuries from 7 to 32 months prior	34	Wrist/hand	QuickDASH		
Ring et al., 2006 [44]	IV	Evaluation at < 3 months since injury	235	Wrist/hand	DASH	X	
						X	

Table 1. continued

Study	Level of evidence	Design	Number	Trauma region	Disability measure	Patient characteristics	Impairment variables
Roh et al., 2014 [46]	II	Prospective longitudinal evaluation at 4 12 24 weeks postoperatively	121	Wrist/hand	MHQ	**X**	
						X	
							X
							X
							X
Roh and Noh, 2015 [47]	III	Prospective longitudinal evaluation at 3 and 6 months F/U	93	Wrist/hand	QuickDASH	**X**	
						X	
							X
							X
Ross et al., 2015 [48]	IV	Evaluation within 28 days of injury or surgery	594	Wrist/hand	QuickDASH		
Shields et al., 2015 [49]	IV	Retrospective evaluation with minimum 1 year F/U	77	Humerus	DASH (overall)	**X**	
					DASH (over 50s)	**X**	
					SST (overall)		
					SST (over 50s)		**X**
					SF-12PCS (overall)	**X**	
					SF-12 (over 50s)		**X**
							X
Symonette et al., 2013 [50]	II	Prospective longitudinal evaluation at baseline and 1 year F/U	291	Wrist/hand	PRWE (1 year)		
Vranceanu et al., 2014 [54]	I	Prospective longitudinal evaluation at 1-2 months and 5-8 months postinjury	136	Arm	SMFA (Time 1)		**X**
							X
					SMFA (Time 2)		**X**
							X
Vranceanu et al., 2015 [55]	I	Randomized controlled trial evaluation within 1-2 months of injury	48	Arm	No relevant analysis of predictors of disability		
Williams et al., 2009 [56]	II	Evaluation at minimum 1 month before injury	106	Wrist/hand	SF-36 PF		
					SF-36 General		

Table 1. continued

Study	Level of evidence	Design	Number	Trauma region	Disability measure	Patient characteristics	Impairment variables
					SF-36 PCS		
Yeoh et al., 2016 [58]	I	Prospective longitudinal evaluation at baseline (7-10 days postinjury) 3 months 1 year	228	Wrist/hand	DASH (12m)		
					SF-36 PCS (12m)		

Study	Psychologic variables	Social variables	Symptoms variables	Prognostic factor	r/t/Z/F	Part R^2	Adjusted R^2 (M)
Bear-Lehman and Poole, 2011 [2]	**X**			**IES-R**	**0.51**		
	X			**IES-R Intrusion**	**0.57**		
	X			**IES-R Hyperarousal**	**0.45**		
Bekkers et al., 2014 [3]	**X**			**NPTQ**	**0.3**	**0.24**	**9.6%**
Bot et al., 2011 [7]				Age	0.286		
				Age at F/U	0.249		
				Elbow flex-ext	-0.263		
				Pro-sup	-0.283		
				Wrist flex-ext	-0.32		
				Radioulnar arc	-0.311		
				Grip strength	**-0.334**	**n/a**	**56%**
				Ipsilateral Injury	n/a	n/a	56%
	X			CES-D	0.276		
	X			**PCS**	**0.261**	**n/a**	**56%**
			X	**Pain (DASH)**	**0.533**	**n/a**	**56%**
			X	**Pain (DASH)**	**0.553**	**n/a**	**40%**
Bot et al., 2012 [8]				Wrist flex	-0.36	0.053	27%
				Wrist ext	-0.27		
	X			CES-D	0.3	0.039	27%
	X			**PCS**	**0.22**	**0.12**	**27%**
	X			PASS-40	0.26		
				Wrist flex	**-0.36**	**0.072**	**39%**
	X			**Opioid pain medication**	**n/a**	**0.24**	**39%**
			X	**Pain (NRS)**	**0.4**	**0.15**	**39%**
Bot et al., 2014 [5]				Injury to enroll (days)	-0.3		
				Sex	**-1.9**	**0.022**	**51%**
	X			**PSEQ**	**-0.5**	**0.062**	**51%**
	X			**PHQ-9**	**0.59**	**0.071**	**51%**
Bot et al., 2014 [6]				Injury to final (days)	-0.31		
				Injury mechanism	**n/a**	**0.14**	**54%**

Table 1. continued

Study	Psychologic variables	Social variables	Symptoms variables	Prognostic factor	r/t/Z/F	Part R^2	Adjusted R^2 (M)
				Other procedures required	-0.27		
	X			PSEQ	-0.59		
	X			**PHQ-9**	**0.59**	**0.43**	**54%**
Cederlund et al., 2010 [9]		**X**		**SOCS**	**n/a**		
		X		**SOCS**	**0.53**		
		X		**SOCS**	**0.43**		
Chan et al., 2009 [10]				No correlations			
Constand et al., 2014 [11]				**C-P alliance**	**0.22**		
				C-P dialogue	**0.2**		
Das De et al., 2013 [12]				**Sex**		**0.041**	
				Diagnosis		**0.142**	**55%**
	X			**TSK**		**0.063**	**55%**
	X			**PCS**		**0.177**	**55%**
		X		**Work status**		**<0.012**	**55%**
Dogu et al., 2014 [15]	**X**			**IES-R (Acute)**	**0.356**	**n/a**	**48%**
	X			**BDI (Acute)**	**0.373**		
	X			**IES-R (Late)**	**0.52**		
	X			**BDI (Late)**	**0.558**		
Döring et al., 2014 [16]				Sex	n/a		
				PROMIS Mobility	n/a		
	X			**PROMIS PI**	**n/a**	**0.33**	**32%**
	X			PHQ-2	n/a		
	X			PSEQ-2	n/a		
		X		Work status	n/a		
		X		Years of education	n/a		
			X	Pain (NRS)	n/a		
				Sex	n/a		
				PROMIS Mobility	n/a		
	X			**PROMIS PI**	**n/a**	**0.6**	**63%**
	X			PHQ-2	n/a		
	X			PSEQ-2	n/a		
		X		**Retired**	**n/a**	**0.059**	**63%**
		X		**Unemployed**	**n/a**	**0.057**	**63%**
		X		Years of education	n/a		
			X	Pain (NRS)	n/a		
Farzad et al., 2015 [17]				**Sex**	**0.24**	**n/a**	**22%**
				AMA impairment	**0.38**	**n/a**	**22%**
				Age	**-0.2**	**n/a**	**23%**
				AMA impairment	**-0.24**	**n/a**	**23%**

Table 1. continued

Study	Psychologic variables	Social variables	Symptoms variables	Prognostic factor	r/t/Z/F	Part R^2	Adjusted R^2 (M)
Golkari et al., 2015 [18]							
Gong et al., 2011 [19]	**X**			**CES-D (w6)**	**n/a**		
	X			**CES-D (w12)**	**n/a**		
	X			**CES-D (w24)**	**n/a**		
Gruber et al., 2014 [20]				PAM (enrolment)	-0.3		
	X			PHQ-2	0.5		
	X			PSEQ	-0.8		
				Age	**0.27**	**n/a**	**40%**
				PAM (enrolment)	-0.31		
				PAM (F/U)	-0.41		
	X			PHQ-2	0.38		
	X			**PSEQ**	**-0.51**	**n/a**	**40%**
		X		Workers' compensation	n/a		
		X		Education	-0.23		
Hageman et al., 2014 [21]	**X**			**PSEQ**	**-0.66**	**n/a**	**35%**
	X			PHQ-2	0.38		
	X			SHAI-5	0.33		
		X		Marital status	n/a		
Helmerhorst et al., 2014 [22]	**X**			**PCS**	**n/a**	**0.7**	
	X			**CES-D**	**n/a**	**0.6**	
			X	Opioid pain medication at 1-2m	n/a		
Janssen et al., 2015 [24]				Sought prior treatment	0.02		
	X			PROMIS PB	n/a		
	X			PROMIS Depression	n/a		
	X			**PROMIS PI**	**n/a**	**n/a**	**64%**
		X		Work status	n/a		**64%**
		X		**Marital status**	**n/a**	**n/a**	
		X		Education	n/a		
			X	**Other pain condition(s)**	**n/a**	**n/a**	**64%**
				Age	**n/a**	**n/a**	**47%**
	X			PROMIS PB	n/a		
	X			**PROMIS Depression**	**n/a**	**n/a**	**47%**
	X			**PROMIS PI**	**n/a**	**n/a**	**47%**
		X		Work status	n/a		
		X		**Marital status**	**n/a**	**n/a**	**47%**
			X	**Other pain condition(s)**	**n/a**	**n/a**	**47%**
			X	Pain (NRS)	n/a		
Jayakumar et al., 2015 [25]				**Sex**	**n/a**	**0.074**	**34%**
	X			**PROMIS PI**	**-0.39**	**0.14**	**34%**

Table 1. continued

Study	Psychologic variables	Social variables	Symptoms variables	Prognostic factor	r/t/Z/F	Part R^2	Adjusted R^2 (M)
	X			PACES	0.31		
	X			PROMIS Depression	0.18		
		X		**Separated/divorced**	**n/a**	**0.079**	**34%**
		X		**Single**	**n/a**	**0.04**	**34%**
		X		Years of education	0.24		
			X	**Other pain condition(s)**	**n/a**	**0.059**	**34%**
Keogh et al., 2010 [28]				**Injury to enroll (days)**	**n/a**	**-0.36**	**55%**
				Fracture type		**0.4**	**55%**
	X			**DASS**	**0.33**	**0.34**	**55%**
	X			ASI	n/a	-0.25	5%
	X			PCS	n/a	0	5%
	X			PASS-20	n/a	-0.13	5%
			X	Pain (SF-MPQ)	0.25		
			X	**Pain (PRWE)**	**0.58**	**0.57**	**55%**
Kortlever and Janssen, 2015 [29]	X			PCS	n/a	0.0117	
	X			PIPS	n/a	0.0003	
	X			**PROMIS PI**	**n/a**	**0.1227**	**57%**
	X			**PSEQ**	**n/a**	**0.0264**	**57%**
Mayland et al., 2017 [32]	**X**			**RRAQ**	**0.446**	**0.19**	**29%**
	X			PASS-20	0.354	0.029	29%
	X			STAI-Trait Anxiety	n/a	0.001	29%
	X			STAI-State Anxiety	n/a	0.008	29%
Niekel et al., 2009 [35]				**Sex**	**n/a**	**n/a**	**25%**
	X			**CES-D**	**0.31**		**25%**
	X			**PCS**	**-0.21**		**25%**
	X			**PASS-40**	**0.31**		**25%**
	X			**CES-D**	**n/a**		**20%**
	X			**PCS**	**n/a**		**20%**
	X			**PASS-40**	**n/a**		**20%**
				Age			**20%**
				Sex			**20%**
	X			**CES-D**	**0.28**		**20%**
	X			**PCS**	**-0.17**		**20%**
	X			**PASS-40**	**0.27**		**20%**
	X			**CES-D**	**n/a**		**13%**
	X			**PCS**	**n/a**		**13%**
	X			**PASS-40**	**n/a**		**13%**
Nota et al., 2016 [37]				**F/U patient**	**30**	**0.038**	**73%**
				New patient	**31**	**0.022**	**73%**
				Trauma	**39**	**0.047**	**73%**
				Nonspecific arm pain	**27**	**0.023**	**73%**

Table 1. continued

Study	Psychologic variables	Social variables	Symptoms variables	Prognostic factor	r/t/Z/F	Part R^2	Adjusted R^2 (M)
	X			**PROMIS PI**	**0.83**	**0.66**	**73%**
	X			PROMIS Depression	0.48		
	X			PROMIS PIIP	-0.36		
		X		PROMIS ES CAT	-0.18		
		X		PROMIS IS CAT	-0.19		
		X		**Separated/divorced**	**51**	**0.021**	**73%**
		X		**Work status**	**63**	**0.025**	**73%**
			X	Other pain condition(s)	28-38		
Novak et al., 2010 [38]				Diagnosis	n/a		
	X			**PDI**	**0.764**		
	X			**IIRS**	**0.653**		
		X		Workers' compensation	n/a		
		X		Work status	n/a		
			X	**Pain (VAS)**	**0.487**		
Novak et al., 2011 [39]				**Age**	**0.16**	**n/a**	**52.7%**
				Injury to enroll (days)	**n/a**	**n/a**	**52.7%**
				Sex	**n/a**	**n/a**	**52.7%**
				Nerve(s) injured	n/a	n/a	52.7%
	X			**PCS**	**n/a**	**n/a**	**52.7%**
	X			**HADS**	**n/a**	**n/a**	**52.7%**
		X		**Workers' compensation**	**n/a**	**n/a**	**52.7%**
		X		**Work status**	**n/a**	**n/a**	**52.7%**
			X	**Pain (VAS)**	**0.51**	**n/a**	**52.7%**
			X	**CISS**	**n/a**	**n/a**	**52.7%**
Novak et al., 2012 [40]	**X**			**PCL-C**	**0.277**		
	X			**PCS**	**0.274**		
	X			**SF-36 MCS**	**-0.293**		
			X	**CISS**	**0.329**		
			X	**Pain (VAS)**	**0.385**		
			X	**Pain (SF-MPQ)**	**0.385**		
Peters et al., 2016 [41]				Sex	-2.3		
				BMI	-0.2		
	X			PROMIS SD	-0.38		
	X			PROMIS PI	**-0.71**	**0.21**	**49%**
	X			PROMIS Depression	-0.44		
		X		Education	0.27		
		X		Work status	4.6		
			X	Other pain condition(s)	2.9		
Prugh et al., 2012 [42]	**X**			**TSK FOI**	**0.47**		
	X			TSK FOP	-0.26		
	X			TSK SOMF	0.36		
	X			FABQ	-0.27		

Table 1. continued

Study	Psychologic variables	Social variables	Symptoms variables	Prognostic factor	r/t/Z/F	Part R^2	Adjusted R^2 (M)
	X			PCS-M	-0.2		
	X			PCS-R	-0.36		
Richards et al., 2011 [43]	**X**			**CES-D**	**0.69**		
	X			**SPTSS**	**0.6**		
	X			**SCS**	**0.52**		
	X			**PSS**	**0.52**		
			X	**Pain (QuickDASH)**	**0.79**		
Ring et al., 2006 [44]				Age	n/a		
				Sex	n/a		
	X			**CES-D**	**0.52***	*DRF only	
	X			**CES-D**	**0.44†**	†All diagnoses combined	
	X			**PASS-40**	**0.31†**		
Roh et al., 2014 [46]				**Age (w12)**	**-0.38**		
				Age (w24)	**-0.39**		
				Fracture (w4)	0.01		
				Fracture (w12)	0.02		
				Fracture (w24)	0.02		
	X			**PCS (w4)**	**-0.41**		
	X			**PASS-20 (w4)**	**-0.44**		
	X			**PASS-20 (w12)**	**-0.4**		
Roh and Noh, 2015 [47]				**External fixation**	**n/a**	**0.07**	**38%**
				Age	**n/a**	**0.09**	**21%**
				HISS	**n/a**	**0.08**	**38%**
				HISS	**n/a**	**0.12**	**21%**
	X			**PCS**	**n/a**	**0.12**	**38%**
	X			**PASS-20**	**n/a**	**0.11**	**38%**
Ross et al., 2015 [48]	**X**			**DASS-21 Depression**	**0.31**	**n/a**	**21%**
	X			DASS-21 Anxiety	0.272		
	X			**DASS-21 Stress**	**0.315**	**n/a**	**21%**
			X	**Pain (NRS)**	**0.344**		
Shields et al., 2015 [49]				**Age**	**n/a**		
	X			**Psychiatric history**	**n/a**		
				Age	**n/a**		
	X			**Psychiatric history**	**n/a**		
				Fracture location	**n/a**		
				Private insurance	**n/a**		
				CCI	**n/a**		
				CCI	**n/a**		
	X			**Psychiatric history**	**n/a**		

Table 1. continued

Study	Psychologic variables	Social variables	Symptoms variables	Prognostic factor	r/t/Z/F	Part R^2	Adjusted R^2 (M)
Symonette et al., 2013 [50]		X		**MOS SSS Overall**	**n/a**	**n/a**	**4.7%**
		X		**MOS SSS ES/IS**	**n/a**	**n/a**	**4.7%**
Vranceanu et al., 2014 [54]				**Multiple injuries**	**n/a**	**n/a**	**29%**
				AIS	**n/a**	**n/a**	**29%**
	X			**CES-D**	**n/a**	**n/a**	**29%**
	X			**PCS**	**n/a**	**n/a**	**29%**
	X			**PASS-20**	**n/a**	**n/a**	**29%**
			X	**Opioid pain medication**	**n/a**	**n/a**	**29%**
				Multiple injuries	**n/a**	**n/a**	**40%**
				AIS	**n/a**	**n/a**	**40%**
	X			**CES-D**	**n/a**	**n/a**	**40%**
	X			**PCS**	**n/a**	**n/a**	**40%**
	X			**PASS-20**	**n/a**	**n/a**	**40%**
				Opioid pain medication	**n/a**	**n/a**	**40%**
Vranceanu et al., 2015 [55]							
Williams et al., 2009 [56]	X			**BDI**	**-0.271**		
	X			**BDI**	**-0.409**		
	X			**BDI**	**-0.288**		
Yeoh et al., 2016 [58]	X			**CES-D <16**	**n/a**		
	X			**CES-D <16**	**n/a**		
	X			**CES-D <16**	**n/a**		
	X			**CES-D <16**	**n/a**		

Most influential factors highlighted in bold; only statistically significant variables are included with levels of significance selected by individual studies (range $p < 0.05$ to < 0.10); univariate/bivariate analysis correlations represented as rtF or Z values; multivariate regression analysis represented as adjusted or shrunken R^2 value with % representing total variance, ie, inclusive of all variables in study; AIS = Abbreviated Injury Scale; AMA = American Medical Association; ASI = Anxiety Sensitivity Index; BDI = Beck Depression Inventory; BMI = body mass index; C-P = clinician-patient; CCI = Charlson Comorbidity Index; CES-D = Center for Epidemiologic Studies-Depression scale; CISS = Cold Intolerance Symptom Severity Questionnaire; DASS = Depression Anxiety Stress Scale; DRF = distal radius fracture; EQ-5D = European Quality of Life Index; ES = emotional support; ext = extension; F/U = followup; FABQ = Fear Avoidance Belief Questionnaire; flex = flexion; FOI = fear of injury; FOP = Fear of Pain; HADS = Hospital Anxiety Depression Scale; HISS = Hand Injury Severity Score; IES-R = Impact of Events Scale-Revised; IIRS = Illness Intrusiveness Rating Scale; IS = instrumental support; M = model; MHQ = Michigan Hand Questionnaire; MOS SSS = Medical Outcome Study-Social Support Survey; MPQ = McGill Pain Questionnaire; n/a = not available; N-S = nonspecific; NPTQ = Negative Pain Thoughts Questionnaire; NRS = numeric rating scale; PACES = Physical Activity Enjoyment Scale; PAM = Patient Activation Measure; Part R^2 = partial R^2; PASS = Pain Anxiety Symptoms Scale; PB = pain behavior; PCL-C = Post-traumatic Stress Disorder Checklist; PCS = Pain Catastrophizing Scale; PCS-M = Pain Catastrophizing Scale-Magnification; PCS-R = Pain Catastrophizing Scale-Rumination; PDI = Pain Disability Index; PF = physical function; PHQ = Patient Health Questionnaire; PI = pain interference; PIIP = Psychosocial Illness Impact; PIPS = Psychological Inflexibility in Pain Scale; Pro = pronation; PROMIS = Patient Reported Outcome Measurement Information System Computer Adaptive Test; PRWE = Patient-Rated Wrist Evaluation; PSEQ = Pain Self-Efficacy Questionnaire; PSS = Perceived Stress Scale; QuickDASH = Quick Disability of the Arm, Shoulder and Hand; RRAQ = Recovery Related Anxiety Questionnaire; SCS = Social Constraints Survey; SD = sleep disturbance; SF = Short Form; SF-36 PCS = Short-form 36 Mental Component Summary; SF-36 PCS = Short-form 36 Physical Component Summary; SHAI = Short Health Anxiety Inventory; SMFA = Short Musculoskeletal Function Assessment; SOCS = Sense of Coherence Scale; SOMF = somatic focus; SPTSS, Screen for Post-traumatic Stress Symptoms; SST = Simple Shoulder Test; STAI = State and Trait Anxiety Inventory; Sup = supination; TSK = Tampa Scale for Kinesiophobia; VAS = visual analog scale.

Overall Strength of Evidence

Heterogeneity of studies in terms of design, diagnoses, outcome measures utilized, and statistical analysis performed meant statistical pooling was not considered feasible or appropriate. A qualitative evaluation and best evidence synthesis was performed instead to summarize the strength of evidence for each variable (Table 3). Although there was strong evidence for a selection of psychologic, social, and symptomatic factors being associated with magnitude of disability (PROMs), a significant number of factors had weak or inconclusive findings. As expected, there were greater numbers of "strong" evidence classifications when interactions were assessed between prognostic variables and combined PROMs of disability.

Other Methods

Strength of evidence for all prognostic variables associated with PROMs of disability was assessed using an established five-tier system that graded strength based on consistency of findings and quality of studies (Table 3) [1]. Positive findings from bivariate and multivariate analyses were utilized to determine the strength of evidence for interactions between variables and each PROM of disability as well as interactions between the variable and PROMs of disability combined. Statistical pooling was considered depending on the homogeneity of study populations, type of prognostic factors, and outcome measures. The overall level of consistency of factors associated with disability was based on observing statistically significant associations in multiple studies, considering the quality of these studies and strength of evidence assessment.

We analyzed studies clearing the screening phase (n = 2628) and calculated a percentage for outcome measurement categories represented within the articles and reported by year of publication (2000–2016). A starting year of 2000 was set to observe this trend because this was around the same time the WHO ICF was being introduced. During screening, we also observed unusual, conflicting, or inappropriate use of (1) terminology related to disability; and/or (2) outcome measures used to represent disability and its contributory factors. The authors agreed on classifying any relevant abstracts into these categories and documenting descriptive notes to inform a subclassification. The benchmarks were based on the WHO ICF definitions, which were used as a reference guide throughout this process, along with a classification of outcome measures into (1) objective, ie, clinician-based questionnaires; (2) subjective, ie, patient-reported outcome measures and scales; and (3) performance-based measures. None of the authors received any form of funding in relation to this work.

Results

Disability after upper extremity injury was most consistently associated with symptoms of depression (in 21 cohorts), pain catastrophizing (an exaggerated negative response to nociception in 13 cohorts), anxiety (negative cognitive, behavioral, and physiological response, with or without a relation to nociception [pain anxiety] in 11 cohorts), pain self-efficacy (confidence in the ability to cope despite pain in eight cohorts), and pain interference (the influence of pain in all aspects of life in seven cohorts) (Table 1). Other psychologic factors such as kinesiophobia (fear of movement), sense of coherence (a person's capacity to cope in situations), nonadaptive pain thoughts, and stress after trauma also demonstrated associations with disability, but these were less consistent based on observations in fewer studies (Table 1), studies of poorer quality (Table 2), or factors that showed weaker strengths of evidence (Table 3).

Six of 14 studies that identified depression as a factor associated with the magnitude of disability also provided some form of clinical grading (range; minimal [19%-26%], mild [4%-17%], moderate [5%-17%], severe or major depression [6%-79%]) [15, 19, 22, 43, 56, 58]. Two of these studies reported patients with depressive symptoms (15% in one study, 29% in the other) and a diagnosis of posttraumatic stress disorder [43, 56]. Pain catastrophizing and pain are shown to be significant predictors of disability after distal radius fractures and both-bone fractures of the forearm in multivariable analysis [7, 8]. Pain intensity represented by the visual analog scale, ordinal numeric rating scale, pain-specific questionnaires, or subscales of patient-reported outcome instruments (eg, McGill Pain Questionnaire, Patient-Rated Wrist Evaluation [PRWE] pain subscale) demonstrated strong correlations with disability [7, 8, 28, 38, 39, 40, 43, 48]. Social factors associated with greater disability included lower education level [24], marital status (specifically being single [25], separated, divorced, or widowed [24, 37]), work/employment status (ie, being off work [24], unemployed [39], unemployed but able to work [16], unemployed and unable to work [37], retired [16]), and being involved in workers' compensation or litigation claims [39] (Table 1). Constructs of social, emotional, and informational support were also found to be associated with disability in the longer term [37, 50]. Objective, clinician-based measures such as diagnosis, Hand Injury Severity Scoring System and American Medical Association impairment scale, and performance-based measures such as ROM (specifically wrist flexion after distal radius fractures) and grip strength were the only impairment-related variables shown to have an association with disability (Table 1). The strongest evidence was for diagnosis and ROM. Age and sex were the only consistent demographic factors influencing disability (n = 10 [24%] and n = 9 [22%], respectively). Specifically,

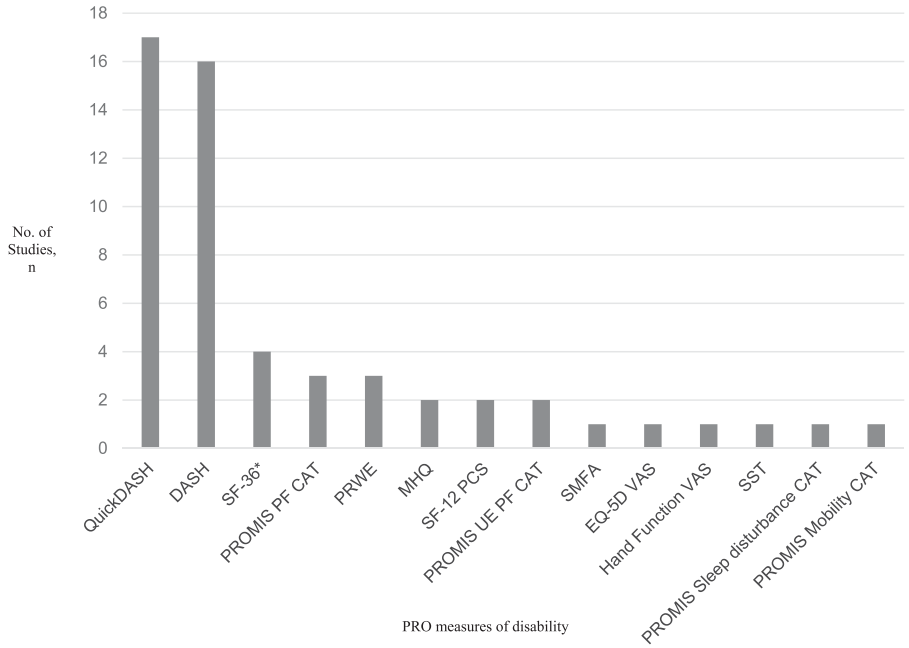

Fig. 3 The distribution of PROMs used in the final inclusion study set is shown. QuickDASH = Quick Disabilities of the Arm, Shoulder and Hand; PROMIS = Patient Reported Outcome Measurement Information System; PF = Physical Function; CAT = Computer Adaptive Test; MHQ = Michigan Hand Questionnaire; PCS = Physical Component Summary Score; UE = upper extremity; SMFA = Short Musculoskeletal Functional Assessment; EQ-5D VAS = European Quality of Life Index; VAS = visual analog scale; SST = Simple Shoulder Test.

being older [17, 20, 24, 35, 39, 46, 47, 49] and being female [5, 17, 25, 35, 54] were associated with greater disability (Table 1). A few longitudinal studies also identified disability itself at baseline or early postinjury as an influential factor of disability at a later stage [15]. In studies performing multivariable analysis with a PROM of disability as the response variable, various prognostic factors explained 10% to 63% of variance (Table 1).

We found a gradual increase in utilization of region or condition-specific PROMs and measures of psychologic and symptomatic factors from 2000 to 2016 (Fig. 4). Use of objective, clinician-based metrics and social factors remained relatively unchanged and use of generic health measures appeared to decline. Seventeen percent of studies (n = 454 of 2628) had cases of unclear, conflicting, or inappropriate terminology. For instance, terms such as functional disability, subjective disability, functional impairment, functional function, and subjective impairment were used without being clearly defined. None of these terms are specified in the WHO ICF, which provides a comprehensive definition of the terms disability and impairment. We accepted that many authors chose to use the terms QoL, function, and derivatives, including functional outcome, interchangeably with disability and so this was not considered an irregularity. Eleven percent of studies (n = 257 of 2628) involved misrepresentations of outcome measures related to disability. For example, one study described wrist accelerometry as a measure of disability when it is more specifically an automated, performance-based measure of impairment, similar to ROM and grip strength. Other instances included the use of PROMs as indicators of patient satisfaction and PROM scores to arbitrarily grade disability as mild, moderate, or severe without any scientific basis.

Discussion

Defining factors associated with disability related to a health condition is integral to understanding the outcomes that matter to individuals and how we should consider their care. Although there is growing evidence for psychosocial factors being the key determinants of health after upper extremity injuries, there is lack of clarity regarding which psychosocial factors have the most consistent association with disability and how the language, conceptualization, and types of measures used to assess disability impact these associations in upper extremity injuries.

We conducted the first systematic review of all studies on upper extremity injury published until December 2016. We found that psychologic and social factors were more consistently associated with disability than factors related

Table 2. Quality assessment of selected studies using a 10-item checklist

Study	I: Demographic data	II: Data collection	III: Diagnosis	IV: Control group	V: Participation/ response rate	VI: Responders/ nonresponders	VII: Outcome measures	VIII: Statistics	IX: Consent	X: Participant selection	Total score
Bear-Lehman and Poole, 2011 [2]	-	+	+	+	-	-	+	+	+	+	7
Bekkers et al., 2014 [3]	+	+	+	-	+	-	+	+	+	+	8
Bot et al., 2011 [7]	+	+	+	+	-	-	+	+	+	+	8
Bot et al., 2012 [8]	+	+	+	-	+	+	+	+	+	+	9
Bot et al., 2014 [5]	+	+	+	-	+	+	+	+	-	+	8
Bot et al., 2014 [6]	+	+	+	+	+	+	+	+	+	+	10
Cederlund et al., 2010 [9]	+	+	-	+	+	-	+	+	+	+	8
Chan et al., 2009 [10]	+	+	-	-	+	+	+	+	+	+	8
Constand et al., 2014 [11]	+	+	+	-	-	-	+	+	+	+	7
Das De et al., 2013 [12]	+	+	+	+	+	-	+	+	+	+	9
Dogu et al., 2014 [15]	+	+	-	-	+	-	+	+	+	+	7
Döring et al., 2014 [16]	+	+	-	-	+	-	+	+	+	+	7
Farzad et al., 2015 [17]	+	+	+	-	-	-	+	+	+	+	7
Golkari et al., 2015 [18]	+	+	+	+	+	-	+	+	+	+	9
Gong et al., 2011 [19]	+	+	+	+	+	-	+	+	-	+	8
Gruber et al., 2014 [20]	+	+	+	-	-	-	+	+	-	+	6
Hageman et al., 2014 [21]	+	+	+	-	+	-	+	+	+	+	8
Helmerhorst et al., 2014 [22]	-	+	-	-	+	-	+	+	+	+	6
Janssen et al., 2015 [24]	+	+	-	-	-	-	+	+	+	+	6
Jayakumar et al., 2015 [25]	+	+	+	+	+	-	+	+	+	+	9
Keogh et al., 2010 [28]	+	+	+	+	+	-	+	+	+	+	9
Kortlever and Janssen, 2015 [29]	+	+	-	-	+	-	+	+	+	+	7
Mayland et al., 2017 [32]	+	+	+	-	-	-	+	+	+	+	7
Niekel et al., 2009 [35]	+	+	+	+	-	-	+	+	-	+	7
Nota et al., 2016 [37]	+	+	+	+	+	-	+	+	+	+	9

Table 2. continued

Study	I: Demographic data	II: Data collection	III: Diagnosis	IV: Control group	V: Participation/ response rate	VI: Responders/ nonresponders	VII: Outcome measures	VIII: Statistics	IX: Consent	X: Participant selection	Total score
Novak et al., 2010 [38]	+	+	+	+	+	-	+	+	+	+	9
Novak et al., 2011 [39]	+	+	+	+	+	-	+	+	+	+	9
Novak et al., 2012 [40]	+	+	+	-	+	-	+	+	+	+	8
Peters et al., 2016 [41]	+	+	+	+	-	-	+	+	+	+	8
Prugh et al., 2012 [42]	+	+	+	-	+	-	+	-	-	+	6
Richards et al., 2011 [43]	+	+	+	-	-	-	+	+	-	+	6
Ring et al., 2006 [44]	+	+	+	+	+	-	+	+	+	-	8
Roh et al., 2014 [46]	+	+	+	+	+	-	+	+	+	+	9
Roh and Noh, 2015 [47]	+	+	+	-	+	-	+	+	+	+	9
Ross et al., 2015 [48]	-	+	+	-	+	-	+	+	+	+	7
Shields et al., 2015 [49]	-	-	+	+	+	-	+	+	-	+	6
Symonette et al., 2013 [50]	+	+	+	-	-	-	+	+	+	+	7
Vranceanu et al., 2014 [54]	+	+	-	+	+	-	+	+	+	+	8
Vranceanu et al., 2015 [55]	+	+	-	+	+	-	+	+	+	+	8
Williams et al., 2009 [56]	+	+	+	+	+	-	+	+	+	+	9
Yeoh et al., 2016 [58]	+	+	+	-	+	-	+	+	-	+	7

Methodological quality assessment of papers–10-item checklist [15, 16]; I Sociodemographic and medical data described (eg, age, race, employment, education, diagnosis); II Process of data collection clearly described (eg, interviews, questionnaires); III Diagnosis described; IV Results are compared between two or more groups (eg, healthy populations, between patient group, etc); V Participation and response rate reported and > 75%; VI Differences between responders/nonresponders are presented when they exist; VII Results are described also for physical, psychologic, and social domains when the quality-of-life measure captures that; VIII Standard statistics (mean, median, ranges, SD) are present for the main study variables; IX Patients signed an informed consent before study participation, and this was explicitly stated in the article; X Selection of participants is adequately described; each item in the selected study that meets criteria is assigned 1 point; if an item does not meet criteria or was described insufficiently, 0 point is assigned; the highest possible score is 10; studies scoring 70% or more of the maximum attainable score (eg, score $\geq$ 7) are arbitrarily considered to be of "high quality"; studies scoring between 50% and 70% are rated as "moderate quality" (score 5-7); studies scoring < 50% are considered "low quality" (score $\leq$ 4).

Table 3. Strength of evidence assessment of factors associated with disability using a five-tier scoring system

Group	Prognostic factor	Cohorts (number)	Level of evidence	Group	Prognostic factor	Depression	Pain Catastrophizing	Pain Interference	Pain Self-Efficacy	(Pain) anxiety	Kinesiophobia	Other/ combined	Cohorts (number)	Level of evidence
Demographic/	Age	10	Strong	Psychological variables	PCS		X						12	Strong
other variables	Sex	9	Strong		CES-D	X							9	Strong
	Injury to enrollment (days)	3	Strong		PROMIS PI CAT			X					6	Strong
	Injury to final evaluation (days)	1	Weak		PSEQ				X				5	Strong
	Injury mechanism	1	Weak		PASS-20					X			5	Strong
	External fixation	1	Weak		PROMIS Depression CAT	X							4	Strong
	Additional procedures required	1	Weak		PASS-40					X			3	Strong
	F/U patient	1	Weak		PHQ-2	X							3	Strong
	New patient	1	Weak		PHQ-9	X							2	Strong
	Clinician-patient alliance	1	Weak		BDI	X							2	Moderate
	Clinician-patient dialogue	1	Weak		SOCS							X	1	Weak
	Sought prior treatment	1	Inconclusive		RRAQ					X			1	Weak
	Private insurance	1	Inconclusive		DASS							X	1	Weak
	PAM (enrollment/FU)	1	Inconclusive		HADS							X	1	Weak
Impairment variables	Diagnosis	6	Strong		ASI					X			1	Weak
	ROM	2	Strong		IIRS			X					1	Weak
	Grip strength	1	Weak		NPTQ				X				1	Weak
	Ipsilateral injury	1	Weak		PACES							X	1	Weak
	PROMIS Mobility	1	Weak		PCL-C							X	1	Weak
	BMI	1	Weak		PDI			X					1	Weak
	HISS	1	Weak		TSK						X		1	Weak
	AIS	1	Weak		PROMIS PIIP CAT							X	1	Weak
	Multiple injuries	1	Weak		PROMIS SD CAT							X	1	Weak
	AMA Impairment Scale	1	Weak		SF-36 MCS							X	1	Weak
	CCI	1	Inconclusive		SHAI-5					X			1	Weak
Social variables	Work status	7	Strong		IES-R							X	2	Weak
	Education	5	Strong		IES-R intrusion							X	1	Weak
	Workers' compensation	3	Strong		IES-R hyperarousal							X	1	Weak
	Separated/divorced	2	Strong		PIPS				X				1	Weak
	Marital status	2	Moderate		DASS-21 anxiety					X			1	Weak
	Single	1	Weak		DASS-21 depression	X							1	Weak
	PROMIS ES CAT	1	Weak		DASS-21 stress							X	1	Weak
	PROMIS IS CAT	1	Weak		PSEQ-2				X				1	Weak
	MOS SSS overall	1	Weak		STAI-Trait anxiety					X			1	Weak
	MOS SSS ES/IS	1	Weak		STAI-State anxiety					X			1	Weak
	Work status retired	1	Weak		Psychiatric history							X	1	Inconclusive

Table 3. continued

Group	Prognostic factor	Cohorts (number)	Level of evidence	Group	Prognostic factor	Depression	Pain Catastrophizing	Pain Interference	Pain Self-Efficacy	(Pain) anxiety	Kinesiophobia	Other/ combined	Cohorts (number)	Level of evidence
	Work status unemployed	1	Weak		PCS-M		X						1	Inconclusive
Symptoms variables	Other pain conditions	4	Strong		PCS-R		X						1	Inconclusive
	Pain (Ordinal NRS)	4	Strong		FABQ					X			1	Inconclusive
	Pain (VAS)	3	Strong		PROMIS PB CAT				X				1	Inconclusive
	Opioid pain medication	3	Strong		PSS							X	1	Inconclusive
	Pain (SF-MPQ)	2	Strong		TSK FOI						X		1	Inconclusive
	CISS	2	Strong		TSK FOP						X		1	Inconclusive
	Pain (QuickDASH)	1	Weak		TSK SOMF						X		1	Inconclusive
	Pain (DASH/ QuickDASH)	1	Weak		SCS							X	1	Inconclusive
	Pain (PRWE)	1	Weak		SPTSS							X	1	Inconclusive

Five-tier scoring system for level of evidence [17]; Strong: consistent findings (≥ 70%) in at least two high-quality studies; Moderate: consistent findings (≥ 70%) in one quality study and at least one moderate or low-quality study; Weak: Findings in one high-quality study or consistent findings (≥ 70%) in at least three or more low-quality studies; Inconclusive: inconsistent findings or less than three low-quality studies; AIS = Abbreviated Injury Scale; AMA = American Medical Association; ASI = Anxiety Sensitivity Index; BDI = Beck Depression Inventory; BMI = body mass index; C-P = clinician-patient; CCI = Charlson Comorbidity Index; CES-D = Center for Epidemiologic Studies-Depression scale; CISS = Cold Intolerance Symptom Severity Questionnaire; DASS = Depression Anxiety Stress Scale; DRF = distal radius fracture; EQ-5D = European Quality of Life Index; ES = emotional support; ext = extension; F/U = followup; FABQ = Fear Avoidance Belief Questionnaire; flex = flexion; FOI = fear of injury; FOP = fear of pain; HADS = Hospital Anxiety Depression Scale; HISS = Hand Injury Severity Score; IES-R = Impact of Events Scale-Revised; IIRS = Illness Intrusiveness Rating Scale; IS = instrumental support; M = model; MHQ = Michigan Hand Questionnaire; MOS SSS = Medical Outcome Study-Social Support Survey; MPQ = McGill Pain Questionnaire; n/a = not available; N-S = nonspecific; NPTQ = Negative Pain Thoughts Questionnaire; NRS = numeric rating scale; PACES = Physical Activity Enjoyment Scale; PAM = Patient Activation Measure; Part R^2 = partial R^2; PASS = Pain Anxiety Symptoms Scale; PB = pain behavior; PCL-C = Post-traumatic Stress Disorder Checklist; PCS = Pain Catastrophizing Scale; PCS-M = Pain Catastrophizing Scale-Magnification; PCS-R = Pain Catastrophizing Scale-Rumination; PDI = Pain Disability Index; PF = physical function; PHQ = Patient Health Questionnaire; PI = pain interference; PIIP = Psychosocial Illness Impact; PIPS = Psychological Inflexibility in Pain Scale; Pro = pronation; PROMIS = Patient Reported Outcome Measurement Information System Computer Adaptive Test; PRWE = Patient-Rated Wrist Evaluation; PSEQ = Pain Self-Efficacy Questionnaire; PSS = Perceived Stress Scale; QuickDASH = Quick Disability of the Arm, Shoulder and Hand; RRAQ = Recovery Related Anxiety Questionnaire; SCS = Social Constraints Survey; SD = sleep disturbance; SF = Short Form; SF-36 PCS = Short-form 36 Mental Component Summary; SF-36 PCS = Short-form 36 Physical Component Summary; SHAI = Short Health Anxiety Inventory; SMFA = Short Musculoskeletal Function Assessment; SOCS = Sense of Coherence Scale; SOMF = somatic focus; SPTSS, Screen for Post-traumatic Stress Symptoms; SST = Simple Shoulder Test; STAI = State and Trait Anxiety Inventory; Sup = supination; TSK = Tampa Scale for Kinesiophobia; VAS = visual analog scale.

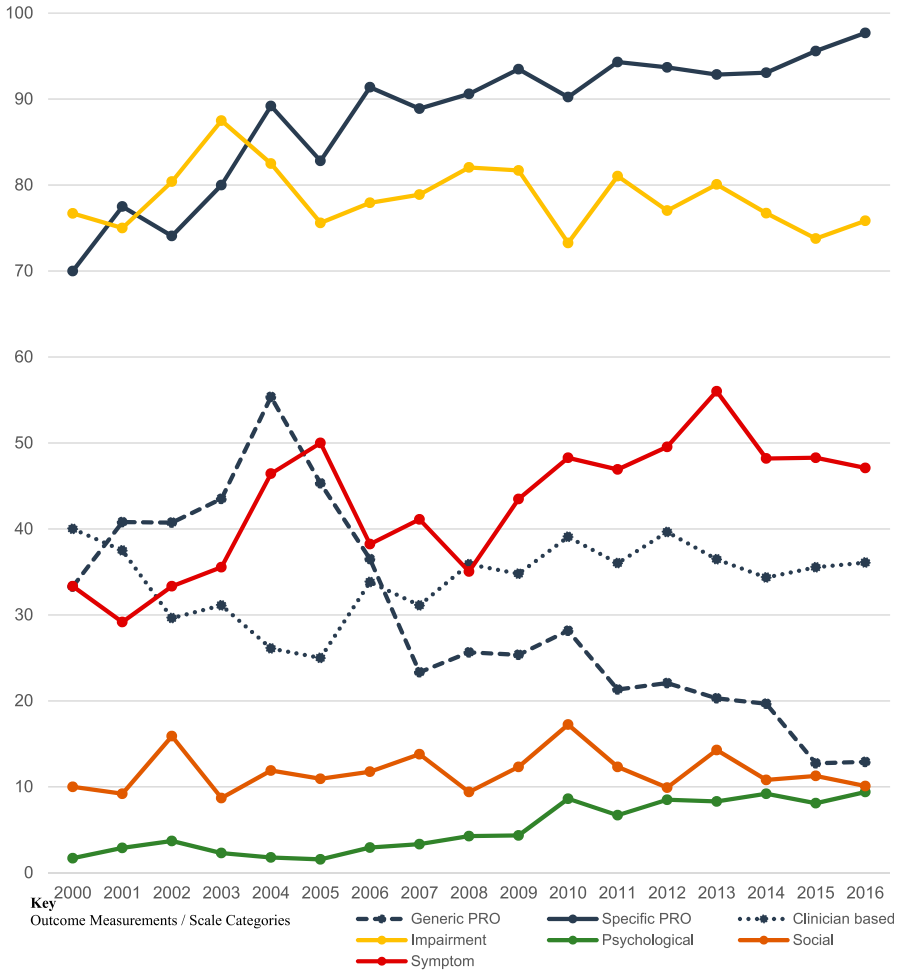

Fig. 4 The annual percentage rate of outcome measurement categories is represented within all published orthopaedic upper extremity articles for year based on the systematic review search criteria (2000-2016).

to impairment. We also observed a substantial number of irregularities in the use of outcome measurement tools and terminology related to disability despite clear guidelines provided by the WHO ICF framework.

This study has several limitations. First, during categorization of the outcome measures into psychologic, social, symptomatic, demographic, and impairment-related factors, it is conceivable that some measurements could fit into more than one of these categories. For example, emotional support (the perceived feelings of being cared for and being valued as a person) could be classed as a psychologic as well as a social factor. Although the constituents of these categories could be debated, a consensus was reached at the outset by our multidisciplinary team of authors and adhered to throughout the study. Second, a degree of selection bias may exist as a result of the broad scope of this review despite following a clear set of inclusion and exclusion criteria throughout the analysis. For instance, a proportion of studies may not have listed all their outcome measures in the abstract, leading to inadvertent exclusion. It was difficult to mitigate this with such a large study set. Third, although this study aimed to assess the association among a comprehensive range of factors with disability, it is dependent on the set of variables chosen by the investigators. It is possible that other determinants associated with disability were not captured and the group of factors selected in this study may not be exhaustive. Fourth, one must acknowledge that these conclusions are made on a broad range of studies with heterogeneous populations (two-thirds of studies involved trauma and nontraumatic conditions combined). Thus, we would recommend readers zone in on an area or factor of interest and consider the study characteristics, data, and populations to which the associations with disability are assigned. Finally, the generalizability of these findings could be questioned because most studies were conducted in US institutions. Cultural and societal differences between US populations

and other parts of the world should be considered when interpreting findings.

Psychologic factors, specifically depression, pain catastrophizing, pain self-efficacy, pain interference, and pain anxiety, along with certain social factors (work, education, marital status) and pain intensity are consistently associated with the magnitude of disability. Impairment-related factors (such as diagnosis or ROM) are comparatively weak. Although psychologic factors impact disability prospectively even after controlling for impairment [33, 36], numerous studies indicate that a large amount of variance in disability remains unexplained. The contextual factors component of the WHO ICF, which is classified into environmental and personal factors, may account for some of this unexplained variance (Fig. 1) [57]. This could be tested by enlisting other forms of PROMs and evaluating their association with disability. For example, environmental factors include relationships and attitudes toward surrounding services, and personal factors include behavioral assets including confidence to cope. These could be quantified by patient experience ratings and patient activation measures, which aim to capture the knowledge, skills, and confidence an individual has in engaging with their own health and their healthcare providers.

Based on our findings, further studies should evaluate the potential impact of early assessment and treatment of psychosocial factors on recovery after upper extremity injury [15, 22, 56]. Interventions such as behavioral activation and cognitive-behavioral therapy (CBT) may counteract nonadaptive cognitions and behaviors, but are seldom used in orthopaedic patients. The single randomized controlled trial in this review found that a CBT-like skill-based intervention was feasible, acceptable, and effective in decreasing pain intensity and magnitude of disability [55]. Further clinical trials are required to assess the impact of mind-body skill-based coaching at different stages of recovery [18, 55]. Quality research in this area may not only provide further evidence to support treatment decision-making, but also a means of diminishing the stigma and shame that patients may experience during assessment of psychosocial factors. Notably, PROMs should only be used as guidance, not mandate, in screening patients and triggering therapies during the recovery trajectory to mitigate the risk of labeling patients with psychologic diagnoses and exposing vulnerabilities [46, 55].

This study also mapped the trends in the tools used to assess disability and inspected articles for variations in terminology describing aspects of disability. In the era of patient-centered care, it is not surprising that there is a relative increase in utilization of condition- and region-specific PROMs. A greater appreciation for psychologic factors may also be reflected by the gradual increase in measures of emotional health. The percentage of measures representing social factors, however, remained largely unchanged. An increasing recognition of the role played by social determinants on health may support the inclusion of a greater number of social factor variables in future work in this field such as nutritional status and housing. In terms of terminology related to disability and its components, and the outcome measures used to quantify them, one assumes there is sufficient understanding of terms before publishing scientific literature. The substantial proportion of abstracts exhibiting unclear, conflicting, and incorrect terminology in this study suggests otherwise. This observation was based on referencing terms against the WHO ICF, which provides a global standard for definitions related to disability and health. Although this framework is well established in healthcare research, it may be less familiar to the broader orthopaedic community given our findings [26, 53]. Disability reflects the interactions between impairment, activity limitations, and participation restrictions and contextual factors in relation to a health condition. It should be represented by PROMs of physical functioning at the level of tasks, broader acts, and roles [51]. Physical functioning represents a person's capacity in certain situations and the ability to manage barriers to this functioning [57]. The term function is applied extremely liberally in clinical practice and research and often represented by a range of measures, often precluding a clear idea of what concept is being measured. Psychosocial factors and pain can be assessed using PROMs and ordinal or numeric rating scales, respectively. Impairment (pathophysiology) can be assessed using objective, clinician-based measures such as radiographic classification or performance-based measures such as grip strength. [51]. Orthopaedic institutions with global networks should consider standard setting for terms and tools related to disability after injuries. This may facilitate better comparisons between studies in this field. Much can be learned from extensive consensus-building work in the area of disability related to chronic pain [51]. A system of research has been endorsed where investigators are encouraged to assess (1) the capacity to physically function; (2) the impact of psychosocial, symptomatic, environmental, and personal stressors on this capacity; and (3) the ability of coping and adaptation to modify the relationship between capacity and actual performance [51]. Standard sets of validated patient-reported, clinician-based, and performance-based measures representing disability and its components are being developed to support such guidance [51].

Psychosocial factors are most consistently associated with the magnitude of disability after upper extremity injuries. Further studies should investigate the impact of early assessment and provision of interventions, eg, coping strategies, behavioral activation, CBT, and social support,

during recovery on long-term PROMs. Intelligent comparison of disability outcomes in this field requires a level standardization in the tools to assess disability and the terminology used to communicate information related to disability. This should be a priority for orthopaedic institutions with networks capable of defining consensus-based standards and disseminating these recommendations internationally. This could be further consolidated at the policy level because the delivery of health care is becoming increasingly guided by patient-reported outcome data and measuring what matters to patients.

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