


# BMJ Open Assessment of patient-reported outcomes after polytrauma – instruments and methods: a systematic review

Michaela Ritschel ,<sup>1</sup> Silke Kuske,<sup>2</sup> Irmela Gnass,<sup>3</sup> Silke Andrich,<sup>1,4</sup> Kai Moschinski,<sup>1</sup> Sandra Olivia Borgmann,<sup>1,4</sup> Annegret Herrmann-Frank,<sup>1</sup> Maria-Inti Metzendorf,<sup>5</sup> Charlotte Wittgens,<sup>1</sup> Sascha Flohé,<sup>6,7</sup> Johannes Sturm,<sup>8</sup> Joachim Windolf,<sup>7</sup> Andrea Icks<sup>1,4</sup>

**To cite:** Ritschel M, Kuske S, Gnass I, *et al.* Assessment of patient-reported outcomes after polytrauma – instruments and methods: a systematic review. *BMJ Open* 2021;**11**:e050168. doi:10.1136/bmjopen-2021-050168

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2021-050168>).

Received 11 February 2021  
Accepted 14 September 2021



© Author(s) (or their employer(s)) 2021. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

For numbered affiliations see end of article.

## Correspondence to

Michaela Ritschel;  
michaela.ritschel@hhu.de

## ABSTRACT

**Objectives** We (1) collected instruments that assess health-related quality of life (HRQoL), activities of daily living (ADL) and social participation during follow-up after polytrauma, (2) described their use and (3) investigated other relevant patient-reported outcomes (PROs) assessed in the studies.

**Design** Systematic Review using the Preferred Reporting Items for Systematic Review and Meta-Analysis guideline.

**Data sources** MEDLINE, Embase, CINAHL, PsycINFO, CENTRAL, as well as the trials registers ClinicalTrials.gov and WHO ICTRP were searched from January 2005 to April 2018.

**Eligibility criteria** All original empirical research published in English or German including PROs of patients aged 18–75 years with an Injury Severity Score  $\geq 16$  and/or an Abbreviated Injury Scale  $\geq 3$ . Studies with defined injuries or diseases (e.g. low-energy injuries) and some text types (e.g. grey literature and books) were excluded. Systematic reviews and meta-analyses were excluded, but references screened for appropriate studies.

**Data extraction and synthesis** Data extraction, narrative content analysis and a critical appraisal (e.g. UK National Institute for Health and Care Excellence) were performed by two reviewers independently.

**Results** The search yielded 3496 hits; 54 publications were included. Predominantly, HRQoL was assessed, with Short Form-36 Health Survey applied most frequently. ADL and (social) participation were rarely assessed. The methods most used were postal surveys and single assessments of PROs, with a follow-up period of one to one and a half years. Other relevant PRO areas reported were function, mental disorders and pain.

**Conclusions** There is a large variation in the assessment of PROs after polytrauma, impairing comparability of outcomes. First efforts to standardise the collection of PROs have been initiated, but require further harmonisation between central players. Additional knowledge on rarely reported PRO areas (e.g. (social) participation, social networks) may lead to their consideration in health services provision.

**PROSPERO registration number** CRD42017060825.

## Strengths and limitations of this study

- This systematic review was based on a comprehensive search strategy and conducted according to a registered and published protocol.
- First systematic review that provides an overview of patient-oriented instruments used in research after polytrauma.
- Throughout the review process, we followed the Preferred Reporting Items for Systematic Review and Meta-Analysis guideline.
- A limitation might be the restriction of the search period and the language.

## INTRODUCTION

Severe injuries represent a leading cause of death and permanent disability.<sup>1</sup> In the central European region, severely injured people are referred to as having a ‘polytrauma’ or being ‘polytraumatised’.<sup>2</sup> A polytrauma is defined as at least two severe injuries in different body regions or organ systems, at least one of which is potentially life-threatening by itself or in combination with others, with an Injury Severity Score (ISS)  $\geq 16$ .<sup>1–4</sup> According to the TraumaRegister DGU®, a German registry that covers patients with severe injuries, the number of patients with polytrauma (ISS  $\geq 16$ ) was 15 651 in 2019.<sup>5</sup> Most affected were men (72%) with a mean age of 46.5 years.<sup>6</sup>

The survival rates after polytrauma have increased lately, bringing the quality of survival into the focus of research. One year after polytrauma, survivors often fail to reach pretraumatic status due to persisting medical problems.<sup>7</sup> Disabilities such as respiratory problems, paraplegia or tetraplegia, prevent 40% from returning to their former workplace.<sup>8–9</sup> They also have an impact on socioeconomic aspects and quality of life.<sup>9–11</sup> Therefore, it is crucial to reduce the short-term and long-term burden after

polytrauma.<sup>9 11</sup> In this context, the patients' perspective on polytrauma outcomes focussing on psychological, physical and social factors is getting more important for the patients themselves, their relatives and health-care professionals.<sup>11 12</sup> Evaluating these patient-reported outcomes (PROs) is essential to complete the holistic assessment of relevant clinical outcomes after injury from a patient's perspective.

To assess the impact of polytrauma on health-related quality of life (HRQoL) and other important PROs, one must consult the person affected directly.<sup>12 13</sup> HRQoL is already being recorded in registers like the Australian Victoria State Trauma Registry. The German TraumaRegister DGU® will also complement its assessment with HRQoL.<sup>14</sup> Activities of daily living (ADL), defined as basic activities to fulfil independent living, along with physical and psychological needs, are meaningful outcome parameters in case of postpolytrauma impairment. In recent years, the concept of social participation has gained more attention in the political context<sup>15</sup> and was therefore included in the review as an outcome of interest, along with HRQoL and ADL. Several working groups have controversially discussed which tools should be applied to assess PROs after polytrauma, at which time points, and in which way.<sup>13 16–24</sup> However, guidelines with clear recommendations are lacking,<sup>13</sup> and no systematic review could be identified.

Therefore, the aim of this systematic review was to:

1. collect instruments assessing HRQoL, ADL and social participation during follow-up after polytrauma.
2. describe their application in detail (e.g. duration of follow-up period, frequency of application and time point of measurements within the follow-up period).
3. investigate which other relevant PROs are additionally assessed in included studies (e.g. pain, depression, anxiety and cognitive function) without detailed analysis.

## METHODS

This systematic review was conducted in line with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guideline (online supplemental file 1).<sup>25</sup>

### Data sources and search strategy

The search was conducted in MEDLINE, Embase, CINAHL (Cumulative Index to Nursing and Allied Health Literature), PsycINFO, CENTRAL (Cochrane Central Register of Controlled Trials), the trials registers ClinicalTrials.gov and WHO ICTRP (WHO International Clinical Trials Registry Platform), initially covering the period from 1 January 2005 until 3 August 2016, with a later update of the search until 5 April 2018. The search period was chosen because since 2005 interest in HRQoL in research and its implication in practice has been growing.<sup>26</sup> As one of our main aims was to collect instruments measuring HRQoL, we decided to include publications beginning with 2005. Our approach is supported by the emerging

importance of PROs in clinical research and their relevance to the future as a complement to clinical data.<sup>27</sup> Furthermore, the search period was selected to capture the most recent developments in research on PROs.

In addition, reference lists of eligible publications were examined. Textwords (tw) and MeSH-terms (mh) like 'polytrauma' (tw), 'multiple trauma' (mh), 'quality of life' (mh), 'activities of daily living' (tw), 'social participation' (mh) and 'pain' (mh) were used. The development of the search strategy was outlined in the study protocol<sup>28</sup> (online supplemental file 2) and is provided in more detail in online supplemental file 3.

### Inclusion and exclusion criteria

The publications included primarily investigated PROs of patients aged 18–75 years with an ISS  $\geq 16$  and/or an Abbreviated Injury Scale (AIS)  $\geq 3$  during a clearly defined follow-up period. All original empirical research published in English or German was included. Publications examining special types of injury or illness—for example, low-energy injuries, single or mono injuries, burn injuries, war injuries or cancer—were excluded. We also excluded some publication types (grey literature, books, abstracts and editorials). Systematic reviews and meta-analyses were not included, too, but screened to identify further appropriate studies. More details about the inclusion and exclusion criteria were published in the study protocol.<sup>28</sup>

### Selection of publications and studies

Four teams with two reviewers each (MR–IG; KM–SK; MR–SOB and AI–AHF) screened the title and abstracts independently. To foster the process of eligibility decisions, the inclusion or exclusion of the first 50 publications was discussed by two reviewers (MR–IG). In a next step, four teams with two reviewers each (MR–IG; KM–SK; MR–SOB and KM–SOB) independently screened the full texts of the remaining publications for final inclusion. A third reviewer (MR, SK or IG) solved disagreements regarding the inclusion of publications for full-text screening and their final inclusion in this review. We identified publications relating to the same study and/or population. For this purpose, extensive research was conducted, and authors of the corresponding publications were contacted. The section 'Characteristics of included publications' outlines how we approached publications dealing with different research questions of the same study, comprising subpopulations drawn from a superior study population, reporting subprojects of a study project or presenting results of the same research question at different follow-up periods.

### Data extraction and analysis

Data extraction was performed according to the requirements of Cochrane reviews.<sup>29</sup> For the first and second aim, two researchers (MR–IG) used a piloted data extraction sheet independently comprising the

following: first author, publication year and country, study design, aim of the study (objective), study population, treatment, applied instruments (incl. modifications), time of measurements, length of follow-up period, method of assessment (application), study results and results of the critical appraisal. Regarding the third aim, the other reported PROs were extracted and categorised in a separate extraction sheet. Narrative content analysis was performed regarding the assessment of HRQoL, ADL and social participation as well as further reported PROs.

### Critical appraisal

Teams with two reviewers each (MR, IG, SK, KM and SOB) independently assessed the methodological quality and the risk of bias in each study type using standardised checklists of the UK National Institute for Health and Care Excellence (NICE),<sup>30,31</sup> Scottish Intercollegiate Guidelines Network (SIGN)<sup>32</sup> or the Mixed-Method Appraisal Tool.<sup>33</sup> Discrepancies were resolved by discussion between the reviewers or by a third reviewer.

### Patient and public involvement statement

Patients were not involved in the design and implementation of this systematic review.

## RESULTS

### Search results

In total, 3485 references were retrieved. After a title and abstract screening as well as a full-text screening, further 11 records were identified by backward citation tracking. Finally, 54 eligible publications were included for data extraction (figure 1).

### Characteristics of included publications

The publications (n=54) most often came from Germany (n=15, 28%) and the Netherlands (n=11, 20%); rarely from Austria, Denmark, France, Japan, Poland, Spain and Sweden (each n=1, 2%). One study has been carried out in Germany and Austria, another one in Europe, Asia, Australia, Africa, North-America and South-America. The publications primarily reported monocentric studies (n=44, 81%) and predominately comprised prospective cohort studies (n=26, 48%) (table 1).

The number of participants varied between 8<sup>34</sup> and 7612,<sup>35</sup> with an average age of 24.6±12.1<sup>36</sup> to 53.9±18.8<sup>37</sup> years and a proportion of men between 37.5%<sup>34</sup> and 84%.<sup>38</sup> The mean ISS ranged between 3.9±1.7<sup>39</sup> and 56.8 points<sup>40,41</sup> and the AIS—reported in 18 publications—between zero and five points. Information regarding treatment of injuries was provided in n=31 publications (table 1).

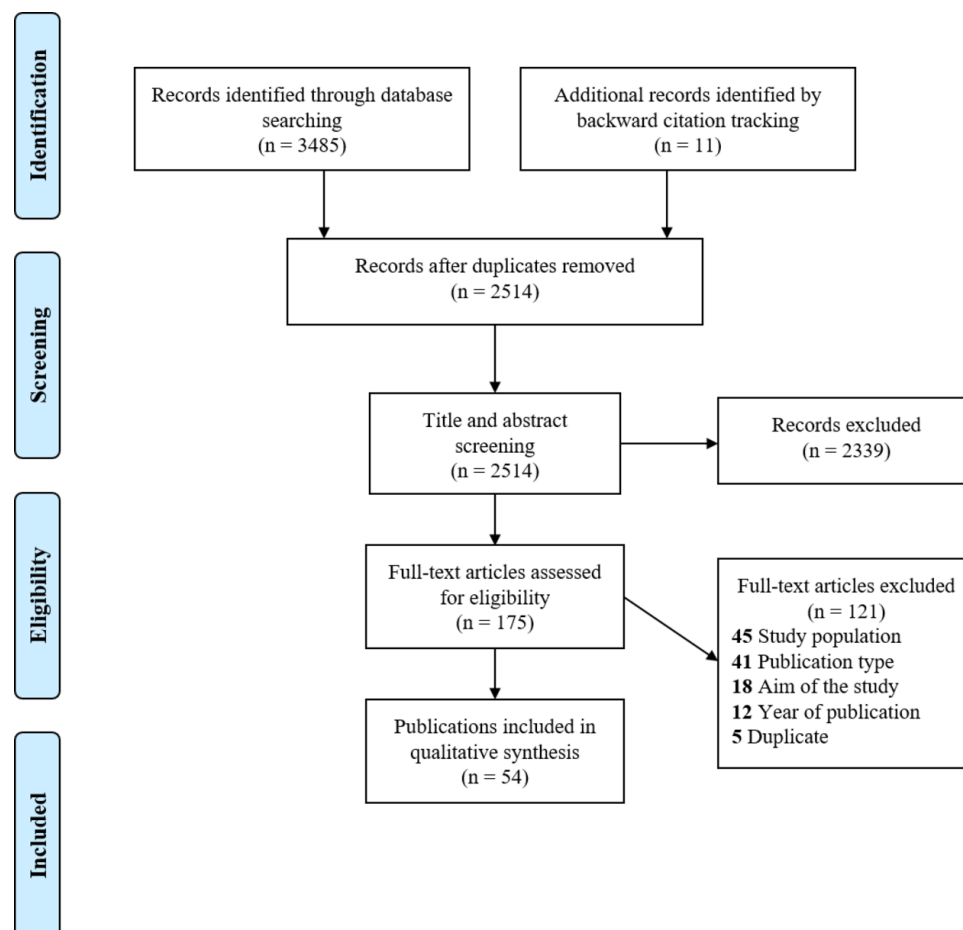


Figure 1 Flow chart

**Table 1** Overview of included publications

| Author, year, country                                  | Study design                           | Objective  | Study population (number: N=(% male), age, ISS/AIS (range, mean±SD/median), kind of injury)   | Treatment  | Instrument(s) for assessment of  |                        |     | Time of measurement/length of follow-up period | Application/setting                      | Results   |
|--|--|--|---|--|----------------------------------|------------------------|-----|--|--|---|
|  |  |  |   |  | QoL/HRQoL                        | (Social) Participation | ADL |  |  |   |
| Abraham <i>et al.</i> <sup>10</sup> 2014<br>USA        | Prospective monocentric cohort study   | Influence of inpatient delirium on HRQoL after polytrauma; association of depressive symptoms and symptoms of PTSD with domains of HRQoL                         | n=115 (65.7)<br>Age: mean 42.4±16.7<br>ISS: 16 →25, mean 30.4±9.2<br>AIS: NR<br>injury: extremity, head/neck (no brain injury), abdomen/pelvis, thorax  | Days intensive care unit (ICU) stay (mean): 9.4±8.2<br>Ventilator days (mean): 3.4±6.4   | SF-36                            | -                      | -   | 1 year after hospital release†                 | Personal, postal or telephone survey; NR | No association between delirium and HRQoL; higher levels of depressive symptoms and symptoms of PTSD associated with lower HRQoL; stronger association of depressive symptoms and HRQoL compared with symptoms of PTSD  |
| Ahnberg <i>et al.</i> <sup>11</sup> 2014<br>Germany    | Retrospective monocentric cohort study | Definition and influence of delayed foot fracture diagnosis on the overall outcome of polytraumatised patients   | n=47 (68.1)<br>Age: Md 39.0<br>ISS: Md 27.0<br>AIS: NR<br>Early fracture diagnosis n=26<br>Age: Md 38<br>ISS: Md 29.0<br>AIS: NR<br>Delayed fracture diagnosis n=21<br>Age: Md 44<br>ISS: Md 27.0<br>AIS: NR<br>Injury: calcaneus, talus, metatarsalia, navicular, cuboid, cuneiformia, phalanges                                     | Conservative and surgical<br>Days ICU stay (Md): 6<br>Early fracture diagnosis<br>Conservative and surgical<br>Days ICU stay (Md): 8.0<br>Delayed fracture diagnosis<br>Conservative and surgical<br>Days ICU stay (Md): 4.0 | SF-36                            | -                      | -   | 3.5–7.75 years, mean 5.67±1.58 years†          | Self-administered questionnaire; NR      | No significant differences between the two groups in clinical scores; no significant effects of delayed foot fracture diagnosis on the outcome of polytraumatised patients  |
| Andruszkow <i>et al.</i> <sup>12</sup> 2013<br>Germany | Retrospective monocentric cohort study | Effects of additional upper extremity injuries or traumatic brain injuries (TBI) on functional, psychological and vocational outcome in polytraumatised patients | Study population of the Hannover rehab study<br>Injury upper extremity n=229 (75)<br>Age: mean 30.2±11.5<br>ISS: mean 20.2±8.6<br>AIS: NR<br>Injury upper extremity and TBI n=92 (72)<br>Age: mean 32.0±11.0<br>ISS: mean 32.1±6.4<br>AIS: NR<br>Injury: upper extremity with and without TBI, chest, abdomen, spine, lower extremity | NR   | HASPOC, SF-12                    | -                      | -   | 10–28 years, Md 17.5 years†                    | NR                                       | Limitations of functional and vocational outcome due to additional upper extremity injuries in polytraumatised patients; no deterioration of long-term outcome in combined injury of the upper extremity with TBI compared with isolated TBI; no difference in the PCS and MCS of SF-12 in all three groups |
| Archer <i>et al.</i> <sup>13</sup> 2012<br>USA         | Prospective monocentric cohort study   | Connection between fear of movement, catastrophising pain, pain and physical health  | n=84 (58)<br>Age: mean 43.1±17.13<br>ISS: mean 30.4±9.5<br>AIS: NR<br>Injury: abdomen, chest, extremities, external, head/face, neck, spine   | Surgical<br>Days ICU stay (mean): 9.3±7.7<br>Ventilator days (mean): 3.4±6.4   | SF-12 (physical component scale) | -                      | -   | 2 years after trauma†                          | NR sent by post                          | Fear of movement and catastrophising pain contributes to poor long-term outcome of polytraumatised patients   |

Continued

**Table 1** Continued

| Author, year, country                                      | Study design  | Objective   | Study population (number: N=(% male), age, ISS/AIS (range, mean±SD/median), kind of injury)   | Treatment | Instrument(s) for assessment of   |                        |     | Time of measurement/length of follow-up period | Results  |
|--|---|---|---|-----------|---|------------------------|-----|--|--|
|  |   |   |   |           | QoL/HRQoL   | (Social) Participation | ADL |  |  |
| Attenberger <i>et al</i> <sup>17</sup> 2012<br>Switzerland | Prospective monocentric cohort study                      | Testing TOP module in the acquisition of long-term results of polytraumatised patients; validation by testing the association with selected variables and test results (criterion validity) and comparison of the results with internationally recognised QoL instruments (convergent validity); testing screening procedure of the TOP | n=117 (75.2)<br>Age: 13–92, mean 39.6±20.5, Md 35.4<br>ISS: 17–45, 27.5±8.2, Md 27.0<br>AIS*: 0–5, mean 0.5±0.58–2.7 ±1.48,<br>Md 0.0–3.0<br>Injury: inter alia brain injury  | NR        | EQ-5D, SF-36, ALOS, NHP<br>TOP† (†dimensions 'pain' and 'function', also preinjury) | –                      | –   | Mean 2.7±0.9 years post-traumat                | Self-administered questionnaire sent by post<br>TOP indicated high rate of relevant problems of polytraumatised people; TOP is a reliable and well-discriminating instrument for recording relevant general HRQoL and trauma-specific aspects, which showed high correlation with other generic outcome measures |
| Baranyi <i>et al</i> <sup>62</sup> 2010<br>Austria         | Retrospective monocentric cohort study                    | Occurrence of full or partial symptoms of PTSD including psychologically pathologically relevant dimensions and QoL in polytraumatised patients; relation of PTSD symptoms with QoL, social support, depressive mood and dissociative symptoms  | n=52 (73.1)<br>Age: mean 37.6±14.2<br>ISS: mean 33.1±12.61<br>AIS: NR<br>Injury: inter alia head  | NR        | SF-36   | –                      | –   | 1 year post-traumat                            | High risk for PTSD and reduced HRQoL in people with polytrauma; lowest HRQoL in patients with full PTSD, followed by patients with partial symptoms and without PTSD; severe dissociative and depressive symptoms; greater limitations in some QoL dimensions  |
| Bouman <i>et al</i> <sup>9</sup> 2017<br>Netherlands       | Prospective, multicentre, non-randomised controlled study | Effectiveness of the Fast Track (FT) rehabilitation programme on QoL and other health-related outcomes in comparison with conventional trauma rehabilitation service  | FT group<br>n=65 (75)<br>Age: 18–75, mean 44.7±16.7<br>ISS: 4–66, mean 22.1±12.8, Md (IQR) 19.5 (±12–29)<br>AIS: NR<br>Non-FT group<br>n=67 (84)<br>Age: 18–73, mean 42.0±16.6<br>ISS: 4–50, mean 29.4±11.2, Md (IQR) 29 (±21–38)<br>AIS: NR<br>Injury: pelvic fracture, musculoskeletal injuries, neuro-trauma/head injuries | NR        | SF-36† (†Baseline (preinjury status))   | –                      | –   | Baseline, 3, 6, 9, 12 months post-traumat††    | Individual interviews, telephone interviews, postal survey; NR<br>Both groups improved their functional status and QoL; FT group showed faster functional recovery at 6 months compared with 9 months of Non-FT group; no different effects observable in both groups at 12 months                               |

Continued



**Table 1** Continued

| Author, year, country  | Study design   | Objective   | Study population (number: N=(% male), age, ISS/AIS (range, mean±SD/median), kind of injury)  | Treatment                 | Instrument(s) for assessment of |                        |     | Time of measurement/length of follow-up period | Application/setting   | Results  |
|--|--|---|--|---------------------------|---------------------------------|------------------------|-----|--|---|--|
|  |  |   |  |                           | QoL/HRQoL                       | (Social) Participation | ADL |  |   |  |
| Burghofer et al <sup>16</sup> 2005 Germany   | Prospective multicentric cohort study                        | Outcome 5 years after major blunt trauma  | n=273 (70.3)<br>Age: mean 37.5, Md: 34<br>ISS:<br>16–25: 29.3%<br>26–50: 63.0%<br>51–75: 7.7%<br>AIS: NR<br>Injury: severe blunt trauma  | NR                        | SF-36                           | –                      | –   | 5 years after trauma‡                          | Self-administered questionnaire or, in case of cognitive impairment, administered by relatives; NR    | Significant differences in QoL between the trauma cohort and a reference population; relevant decrease of QoL in patients with initial unconsciousness and in severely injured patients; high proportion of patients with persisting pain (headache and lower limb pain); 61.7% were back in occupation, 43.5% of these in the former profession |
| Christensen et al <sup>16</sup> 2011 26 countries in Europe, Asia, Australia, Africa, North- and South-America | Prospective multicentric randomised placebo-controlled study | Identification of HRQoL dimensions most affected by polytrauma and predictors of poor HRQoL | n=347 (75)<br>Age: mean 39±14<br>ISS: mean 31±11, Md 29<br>AIS*: 4+<br>Injury: abdomen, chest, external, extremity, face, head or neck   | ICU stay (duration NR)    | POLO chart                      | –                      | –   | 3 months post-trauma‡                          | Self-administered questionnaire; NR   | Notable reduced HRQoL in polytrauma survivors; physical well-being more affected than mental; greater mental impairment detectable by trauma-specific HRQoL instruments than by generic tools; demographic and socioeconomic characteristics as well as type of injury and treatment predict HRQoL   |
| Dienstknecht et al <sup>13</sup> 2013 Germany  | Retrospective monocentric cohort study                       | Functional and socioeconomic long-term results in patients with pelvic ring fractures       | Study population of the Hannover Rehab study<br>n=109 (72)<br>Age: 5–55, mean 28.8<br>ISS: 16–44, mean 22.7<br>AIS: NR<br>Injury: anterior, posterior and combined pelvic ring injuries, upper and lower limb fracture, thoracic injury, abdominal injury, spine fracture, neurological lesion of lower limb | Conservative und surgical | HASPOC, SF-12                   | –                      | –   | 10–27 years post-trauma, mean 16 years‡        | Self-administered questionnaire as well as assessment via physician; examination in the trauma centre | Long-term functional limitations and socioeconomic effects of pelvic ring fractures; reduced QoL in patients with anterior and combined anterior and posterior pelvic ring injuries  |

Continued

**Table 1** Continued

| Author, year, country                                  | Study design                           | Objective  | Study population (number: N=(% male), age, ISS/AIS (range, mean±SD/median), kind of injury)   | Treatment                      | Instrument(s) for assessment of   |                        |     | Time of measurement/length of follow-up period                    | Application/setting                          | Results  |
|--|--|--|---|--------------------------------|---|------------------------|-----|---|--|--|
|  |  |  |   |                                | GoL/HRQoL   | (Social) Participation | ADL |   |  |  |
| Frénisy <i>et al</i> <sup>81</sup> 2006<br>France      | Prospective monocentric cohort study   | Comparison of neurobehavioral and psychopathological disorders between patients with severe brain injuries (SBI) and patients after polytrauma (MULT)      | SBI n=25 (80)<br>Age: mean 26.97±9.58<br>ISS: mean 25.36±10.80<br>AIS: NR<br>Injury: brain<br>MULT n=25 (72)<br>Age: mean 33.78±10.42<br>ISS: mean 22.04±10.06<br>AIS: NR<br>Injury: bone fractures, thorax, abdomen  | NR                             | -   | -                      | -   | 6–24 months†<br>SBI<br>Mean 1.02±0.39‡<br>MULT<br>Mean 0.93±0.41‡ | Face-to-face interview; NR                   | Similar psychopathological disorders in both groups; SBI-patients show significantly more neurobehavioral disorders and more obsessive symptoms; presence of cognitive disorders in MULT-patients  |
| Gribnau <i>et al</i> <sup>82</sup> 2008<br>Netherlands | Retrospective monocentric cohort study | Injury characteristics, choice of treatment and QoL of people with U-shaped sacral fractures   | n=8 (37.5)<br>Age: 19–55, Md 29<br>ISS: 17–45, Md 23<br>AIS: NR<br>Injury: skull fracture, subdural haematoma, facial fracture, thoracic injury (multiple rib fractures, pneumothorax, haemopneumothorax, sternal fracture, lung contusion), retroperitoneal haematoma, liver laceration  | Surgical                       | EQ-5D   | -                      | -   | 5–65 months post-trauma, Md 36 months‡                            | Self-administered questionnaire sent by post | Pain, mood disorders and moderate mobility problems dominate QoL   |
| Gross <i>et al</i> <sup>48</sup> 2010<br>Switzerland   | Prospective monocentric cohort study   | Long-term work ability of patients after polytrauma; association of capacity to work with internationally accepted variables of functional outcomes or QoL | n=115 (76)<br>Age: 14–92, mean 39.5±20.6<br>ISS: mean 27.5±8.2<br>AIS: mean 2.6±1.5<br>Reduced capacity to work<br>n=61 (79)<br>Age: mean 39.4±20.2<br>ISS: mean 30.2±7.7<br>AIS*: mean 0.5±0.6–3.1±1.5<br>Non-reduced capacity to work<br>n=54 (72)<br>Age: mean 39.6±21.2<br>ISS: mean 24.3±7.7<br>AIS*: mean 0.5±0.5–2.6±1.6<br>Injury: NR | Days ICU stay (mean): 8.4±12.5 | EQ-5D†, SF-36†, NHP (†Baseline (preinjury status) assessed in hospital)                             | -                      | -   | Inpatient stay, Md 2.5 (2.0; 3.3) years post-trauma§              | Self-administered questionnaire sent by post | 50% show reduced capacity to work; reduced QoL and persistent pain compared with the prepolytrauma condition; patient, injury, and treatment variables have impact on capacity to work; association of capacity to work with long-term results such as various functional outcomes, symptom status and QoL |
| Gross and Amsler <sup>49</sup> 2011<br>Switzerland     | Prospective monocentric cohort study   | Prevalence and severity of pain after polytrauma compared with preinjury status using different pain measures; association of pain and HRQoL               | n=102 (74)<br>Age: mean 39.7±20.5<br>ISS: mean 27.1±8.0<br>AIS: NR<br>Injury: NR  | NR                             | EQ-5D†, SF-36†, NHP, TOP (†separate questionnaire for retrospective assessment of preinjury status) | -                      | -   | Mean 2.7±0.9 years post-trauma, Md 2.4 yearst                     | Self-administered questionnaire sent by post | Pain in 85% of patients after polytrauma; higher prevalence and severity of pain compared with preinjury status; close correlation of posttraumatic pain with HRQoL and reduced capacity to work; differences in type and sensitivity of pain measures   |

Continued

**Table 1** Continued

| Author, year, country                                      | Study design                         | Objective  | Study population (number: N=(% male), age, ISS/AIS (range, mean±SD/median), kind of injury)  | Treatment                            | Instrument(s) for assessment of   |  |   | Time of measurement/length of follow-up period   | Application/setting   | Results   |
|--|--------------------------------------|--|--|--------------------------------------|---|--|---|--|---|---|
|  |                                      |  |  |                                      | QoL/HRQoL   | (Social) Participation                                   | ADL   |  |   |   |
| Gross <i>et al</i> <sup>60</sup><br>2012<br>Switzerland    | Prospective monocentric cohort study | QoL and functional outcomes after polytrauma compared with preinjury status; discriminatory potential of different outcome scores between survivors with and without TBI               | n=111 (75)<br>Age: mean 39.5±20.9<br>ISS: mean 27.9±8.2<br>AIS*: mean 0.5±0.6–2.7±1.5<br>Patients with TBI<br>n=45<br>Age: NR<br>ISS: mean 31.1±7.3<br>AIS*: mean 0.7±0.6–3.9±0.7<br>Patients without TBI<br>n=66<br>Age: NR<br>ISS: mean 25.7±8.1<br>AIS*: mean 0.4±0.6–2.6±1.6<br>Injury: inter alia TBI | Days ICU stay (mean): 8.9±12.6       | EO-5D†, SF-36†, NHP, TOP (†separate questionnaire for retrospective assessment of preinjury status) | -  | -   | Mean 2.7±0.9 years post-trauma, Md 2.5 years†  | Self-administered questionnaire sent by post  | Notable reduced QoL and functional outcomes compared with preinjury status; worse outcomes in patients with TBI; SF-36 and NHP discriminate between patients with and without TBI |
| HlIdaki <i>et al</i> <sup>78</sup><br>2009<br>Poland       | Prospective monocentric cohort study | Comparison of QoL after polytrauma in three consecutive 5-year periods using ICIDH   | n=827 (71)†<br>Age: mean 44.7<br>ISS: mean 27.6<br>AIS: NR<br>Injury: head/neck, thorax, abdomen, pelvis and its organs, spinal column and spinal cord, upper and lower limbs  | Surgical                             | ICIDH (only impairments)  | -  | -   | 3 years after completion of inpatient treatment†                                       | NR; outpatient clinic   | Reduced QoL in 50% of patients after polytrauma; improvement of QoL in one of four patients over 15 years   |
| Holtslag <i>et al</i> <sup>62</sup><br>2006<br>Netherlands | Prospective monocentric cohort study | Description of the characteristics of lower extremity injuries in patients after polytrauma and functional long-term outcomes using all domains of ICF and HRQoL and their association | n=186 (75)<br>Age: 16–96, mean 37±17<br>ISS: mean 25±11<br>AIS: NR<br>Injury: lower extremity injuries, pelvic injuries, TBI   | Days ICU stay (mean): (range: 1–123) | SIF, SF-36  | Assessment of criteria such as return to sports and work | 10–18 months post-trauma, mean 14±1.6 months, Md 14 months‡ | Self-administered questionnaire (if necessary, administered by relatives) sent by post | Serious long-term problems of mobility, activity and participation; mild to moderately limited HRQoL; low association of ICF domain functionality with HRQoL; limited concordance between instruments   |   |
| Holtslag <i>et al</i> <sup>61</sup><br>2007<br>Netherlands | Prospective monocentric cohort study | Long-term functional health status in patients after polytrauma; relationship between personal and injury-related characteristics vs long-term HRQoL                                   | n=335 (74)<br>Age: mean 37.7±17.1<br>ISS: mean 24.9±10.6<br>AIS: NR<br>Injury: cranial, facial, upper extremity, chest, abdomen, pelvis, femur, lower leg, spine, spinal cord, peripheral nerve  | Days ICU stay (mean): 12.9±18.7      | SIP   | -  | 12–18 months post-trauma, mean 45±47 days†                  | Self-administered questionnaire sent by post   | Long-term mild to moderately limited HRQoL; lower QoL in young male patients and patients with TBI, spinal cord and extremity injuries; greatest limitations in some SIP categories (work, ambulation, home management, recreation and pastimes, alertness behaviour); comorbidity strong predictor of SIP scores |   |

Continued



Table 1 Continued

| Author, year, country                                  | Study design                           | Objective   | Study population (number: N=(% male), age, ISS/AIS (range, mean±SD/median), kind of injury)  | Treatment                       | Instrument(s) for assessment of |                        |     | Time of measurement/length of follow-up period | Application/setting  | Results   |
|--|--|---|--|---------------------------------|---------------------------------|------------------------|-----|--|--|---|
|  |  |   |  |                                 | QoL/HRQoL                       | (Social) Participation | ADL |  |  |   |
| Holtslag <i>et al</i> <sup>2</sup> 2007<br>Netherlands | Prospective monocentric cohort study   | Long-term functional consequences from polytrauma, quantification of the influence of sociodemographic, injury-related and physical factors on outcomes                                   | n=335 (74)<br>Age: mean 37.7±17.1<br>ISS: mean 24.9±10.6<br>AIS: NR<br>Injury: brain, chest, abdomen, spinal cord, lower extremity, upper extremity                            | Days ICU stay (mean): 12.9±18.7 | EQ-5D                           | -                      | -   | 12-18 months post-trauma, mean 451±47 days†    | Self-administered questionnaire (if necessary, administered by relatives) sent by post                     | Restriction of mobility, self-care and everyday activities, indication of pain and discomfort, anxiety and depression as well as cognitive complaints; localisation of injury, educational level and comorbidities are important independent predictors of long-term functional outcomes after polytrauma; better QoL via EQ-VAS than via utility score |
| Holtslag <i>et al</i> <sup>2</sup> 2008<br>Netherlands | Prospective monocentric cohort study   | Impact of trauma on health in terms of burden of injury, years lived with disability in non-fatal diseases, years of life lost in fatal diseases and disability-adjusted life year (DALY) | Fatalities n=567 (62.6)<br>Age: mean 48.4±23.3<br>ISS:>15<br>AIS: NR<br>Injury: NR<br>Severely injured n=335 (74.3)<br>Age: mean 37.7±17.1<br>ISS:>15<br>AIS: NR<br>Injury: NR | NR                              | EQ-5D                           | -                      | -   | 12-18 months after injury, mean 451±47 days†   | NR   | Substantial loss of healthy life years; at individual level, major trauma contributed an average of 25 DALYs to the burden of disease; at population level, major trauma caused 10 DALYs per 1000 inhabitants   |
| Jackson <i>et al</i> <sup>2</sup> 2007<br>USA          | Retrospective monocentric cohort study | Prevalence of and risk factors for persistent cognitive impairment as well as emotional and functional difficulties in people without intracranial haemorrhage                            | n=88 (67)<br>Age: mean 45.0±14.3<br>ISS: 33.0±6.8<br>AIS: NR<br>Injury: concussion, skull fracture   | NR                              | SF-36                           | -                      | -   | 12-24 months after hospital discharge†         | Administered by a neuropsychologist or a psychometrist; evaluation at medical centre or place of residence | Substantial prevalence of persistent cognitive impairment, emotional dysfunction and functional decrements; most of all in people with concussion and skull fracture compared with those without these injuries; cognitive impairment was associated with functional deficits, poor QoL and an inability to return to work                              |

Continued

**Table 1** Continued

| Author, year, country                                      | Study design                           | Objective  | Study population (number: N=(% male), age, ISS/AIS (range, mean±SD/median), kind of injury)  | Treatment  | Instrument(s) for assessment of |                        |               | Time of measurement/length of follow-up period  | Application/setting  | Results  |
|--|--|--|--|--|---------------------------------|------------------------|---------------|---|--|--|
|  |  |  |  |  | QoL/HRQoL                       | (Social) Participation | ADL           |   |  |  |
| Kaske et al. <sup>77</sup> 2014<br>Germany                 | Retrospective monocentric cohort study | Assessment of HRQoL using a trauma-specific instrument (POLO chart) in patients after polytrauma | n=129 (66.9)<br>Age: mean 43.9±17.5<br>ISS: mean 21.5±13.3<br>AIS: ≥2<br>Injury: lower extremity, thorax, upper extremity, head, spine, pelvis, abdomen  | Days ICU stay (mean): 9.2±9.6, Md (IQR <sub>25-75</sub> ): 5 (2-14)<br>Ventilator days (mean): 8.2±7.6, Md (IQR <sub>25-75</sub> ): 5 (2-14) | POLO chart                      | -                      | -             | Mean 24 months±6 months post-traumat  | Self-administered questionnaire sent by post   | Physical impairments, mental and socioeconomic deficits in patients after polytrauma; reduced HRQoL in 64% of patients 2 years after polytrauma, in half of these patients severely impaired HRQoL; TOP is able to identify impairments and to guide rehabilitation resources                                      |
| Leiferger et al. <sup>69</sup> 2012<br>Germany and Austria | Diagnostic study                       | Phase IV validation of the trauma-specific TOP module as part of the POLO chart                  | Trauma group<br>n=172 (73.8)<br>Age: mean 38.8±14.4<br>ISS: 8-75, mean 26.7±11.2<br>AIS: NR<br>Control group<br>n=166 (65.1)<br>Age: mean 42.9±15.0<br>ISS: 1-9, mean 3.9±1.7<br>AIS: NR<br>Injury: NR                     | NR   | POLO chart                      | -                      | Barthel Index | Trauma group<br>Mean 24.2±18.7 months post-traumat<br>Control group<br>Mean 26.4±14.2 months post-traumat | NR, visit to the hospital for a physical examination and to fill in the questionnaires | Significant differences in all QoL dimensions between trauma and control group; apart from physical domains, also impairment of other dimensions of QoL; results show good discriminatory abilities of the TOP and support its precision in collecting all relevant components of QoL in patients after polytrauma |
| Lippert-Grüner et al. <sup>65</sup> 2007<br>Germany        | Prospective cohort study               | HRQoL in patients with and without concomitant polytrauma  | n=49 (78)<br>Age: 15-68, Md 32<br>ISS: NR<br>AIS: NR<br>Isolated TBI<br>n=28<br>Age: mean 36<br>ISS: mean 27<br>AIS: NR<br>TBI and polytrauma<br>n=21<br>Age: mean 26<br>ISS: mean 40<br>AIS: >3<br>Injury: cranial injury | ICU (duration NR)  | SF-36                           | -                      | -             | 6 and 12 months post-trauma§  | Self-administered questionnaire; during outpatient follow-up examinations              | Comparable results for patients with severe TBI with and without concomitant polytrauma in SF-36 with the exception of physical function; indication of TBI as an important factor for HRQoL and outcomes after trauma; improvement of HRQoL over time   |
| Livingston et al. <sup>60</sup> 2009<br>USA                | Prospective monocentric cohort study   | Long-term outcome of patients with prolonged (>10 days) ICU stay                                 | n=100 (81)<br>Age: 18-94, mean/Md 42<br>ISS: 26-30, mean/Md 28<br>AIS: 3-5<br>Injury: TBI, extremity fracture, pelvis fracture, lower extremity fracture   | Surgical<br>Days ICU stay: 19-24, mean 21, Md 19<br>Ventilator days: mean 16, Md 14  | -                               | -                      | -             | 2.1-5.0 years, mean/Md 3.3 years†   | Telephone interview with patient   | Overall self-reported QoL is generally good with significant impairments incl. inability to return to work (less than 50%) or regain preinjury level of activity and reintegration into society  |

Continued

**Table 1** Continued

| Author, year, country                         | Study design   | Objective  | Study population (number: N=(% male), age, ISS/AIS (range, mean±SD/median), kind of injury)  | Treatment   | Instrument(s) for assessment of  |                        |     | Time of measurement/length of follow-up period  | Application/setting   | Results  |
|---|--|--|--|---|--|------------------------|-----|---|---|--|
|   |  |  |  |   | QoL/HRQoL  | Participation (Social) | ADL |   |   |  |
| Marasco et al <sup>67</sup> 2015<br>Australia | Retrospective monocentric cohort study               | Long-term morbidity and QoL in patients with rib fractures   | n=397 (75)<br>Age: mean 53.9±18.8<br>ISS: mean 22.5±11.8<br>AIS: NR<br>Thoracic group<br>n=216<br>Age: NR<br>ISS: mean 16.0±7.3<br>AIS: max. 3<br>Polytrauma group<br>n=181<br>Age: NR<br>ISS: mean 30.1±11.6<br>AIS: max. 4<br>Injury: head, neck, face, spine, thorax, abdomen, upper and lower extremity      | NR  | SF-12  | -                      | -   | 6, 12, 24 months post-trauma <sup>†</sup>   | Telephone interview with patient (if necessary, with proxy)         | Significantly reduced QoL 24 months after multiple rib fractures; low return to work rate after 6 months; no differences between the groups in pain and QoL; limited function of the thorax group  |
| Mc Carthy et al <sup>65</sup> 2006<br>USA     | Retrospective monocentric cohort study               | Subjective psychosocial health of a population-based sample of adults with TBI   | n=7612 (63.9)<br>Age: 15–75+, mean 43.2±20.0<br>ISS: 4–18+, mean 13.7±7.6<br>AIS: 2–5<br>Injury: TBI   | NR  | SF-36 (psychosocial health scales MCS)                                       | -                      | -   | 1 year after injury±3 months <sup>†</sup>   | Telephone interview   | 29% reported poor psychosocial health 1 year after injury; less than 50% received mental health services; a high proportion reported unmet needs for mental health services  |
| Ouellet et al <sup>65</sup> 2009<br>Canada    | Retrospective multicentric cohort study              | Comparison of mental health in patients with polytrauma with and without TBI; factors associated with low mental health; perceived need for and access to mental health-related services | n=405 (64.6)<br>Age: mean 41.1±15.1<br>ISS: mean 23.6±11.7<br>AIS: NR<br>Patients with TBI<br>n=239 (64.9)<br>Age: mean 37.4±14.5<br>ISS: mean 27.9±9.1<br>AIS: NR<br>Patients without TBI<br>n=166 (61.0)<br>Age: mean 46.4±14.5<br>ISS: mean 15.7±8.4<br>AIS: NR<br>Injury: TBI, spine, upper limb, lower limb | Days ICU stay (mean):<br>TBI: 10.3±14.3<br>Non-TBI: 4.2±8.2 | SF-12, V.2 (MCS as well as all subscales which are related to mental health) | -                      | -   | 2–4 years post-traumat <sup>†</sup><br>Mean 3.3±0.7 years post-traumat <sup>†</sup> without TBI<br>Mean 3.3±0.8 years post-traumat <sup>†</sup> | Telephone interview with patients; NR                               | Not significantly lower MCS-scores in polytrauma patients with TBI compared with patients without TBI; association of 6 factors with low mental health: age, sex, time since trauma, social support, pain and cognitive deficits; high need for mental health-related services but considerable difficulties in maintaining it |
| Overgaard et al <sup>66</sup> 2011<br>Denmark | Prospective cross-sectional monocentric cohort study | Outcome 6–9 years after moderate to severe injury in terms of survival, HRQoL and employment status  | n=322 (71)<br>Age: 15–89, Md 34<br>ISS: 9–75, Md 17<br>AIS: NR<br>Injury: blunt trauma   | Surgical<br>Days ICU stay: 1–62, Md 4                       | SF-36  | -                      | -   | 6–9 years after admission, Md 7.4 years <sup>†</sup>  | Self-administered questionnaire sent by post or telephone interview | 78% of the patients survived the trauma; HRQoL was significantly lower for injured patients than a matched control group; 20% retired early  |

Continued

Table 1 Continued

| Author, year, country                                       | Study design                           | Objective   | Study population (number: N=(% male), age, ISS/AIS (range, mean±SD/median), kind of injury)   | Treatment   | Instrument(s) for assessment of |                        |     | Time of measurement/length of follow-up period  | Application/setting   | Results  |
|---|--|---|---|---|---------------------------------|------------------------|-----|---|---|--|
|   |  |   |   |   | QoL/HRQoL                       | Participation (Social) | ADL |   |   |  |
| Post <i>et al</i> <sup>11</sup><br>2006<br>Netherlands      | Retrospective monocentric cohort study | Return-to-work status and QoL in patients after polytrauma; analysis of injury-related parameters in relation to functional outcome   | n=53 (81)<br>Age: 19–64, mean 37.3±13.2, Md 34.0<br>ISS: 16–54, mean 23.5±8.2, Md 21.0<br>AIS: Md 0–5, 2.0–3.0<br>Injury: head, neck, face, thorax, abdomen, extremities, external  | NR  | SIP                             | –                      | –   | 1.3–2.2 years post-trauma, mean 1.8±0.3 years, Md 1.8 yearst                                | Self-administered questionnaire sent by post  | Most patients after polytrauma return to their former work; compared with general population and less severely injured patients good QoL results; age, but not trauma severity or TBI is a predictor for long-term disablement |
| Probst <i>et al</i> <sup>44</sup><br>2010<br>Germany        | Retrospective monocentric cohort study | Association of improved short-term outcomes after polytrauma with gender differences; long-term follow-up using QoL and rehabilitation status                                 | Study population of the Hannover Rehab study n=637 (75.4)<br>Age: M: mean 26.7±12.2 F: mean 25.9±13.0<br>ISS: M: mean 20.4±9.9 F: NR, 21.7±9.7<br>AIS: M: Md 1–5 F: Md 1–6<br>Injury: head, face/neck, thorax, abdomen, skeletal system | Days ICU stay (mean): M: 15.4±25.0 F: 12.9±23.2<br>Ventilator days (mean): M: 11.2±13.3 F: 9.9±12.5 | HASPOC, SF-12                   | –                      | –   | M: 17.5±4.8 years post-trauma, F: 17.4±5.0 years after trauma†                              | Interview with patients; assessment via physician and physical examination in the trauma centre | After polytrauma, more severe long-term limitations in women than men; no differences in rehabilitation status; longer sick leave times, significantly lower QoL and higher rates of PTSD and psychological support in women   |
| Quale <i>et al</i> <sup>62</sup><br>2009<br>Norway          | Prospective monocentric cohort study   | Incidence and risk factors of post-traumatic stress symptoms (PTSS)   | n=79 (74.7)<br>Age: mean 37±14.3<br>ISS: mean 25.6±12.3<br>AIS: NR<br>Injury: spinal cord, head   | Days ICU stay (mean): 62±61.4<br>Ventilator days (mean): 5.8±13.1                                   | –                               | –                      | –   | 1–3 weeks after admittance to rehabilitation, median days since injury 39, quartiles 24–57‡ | Semistructured interviews, questionnaires; NR   | Low incidence of PTSD, but higher incidence of PTSS; anxiety, female gender, negative attitudes towards emotional expression are risk factors for PTSS   |
| Renovell-Ferrer <i>et al</i> <sup>67</sup><br>2017<br>Spain | Prospective monocentric cohort study   | Comparison of aetiology, severity and functional outcome of people with operated displaced intra-articular calcaneal fractures between polytrauma patients and isolated cases | n=80 (71)<br>Age: 16–74, mean 48.4, Md 47<br>ISS:>16 (14%)<br>AIS: NR<br>Injury: intra-articular calcaneal fractures, pelvic fracture, spine fracture   | Surgical  | SF-36                           | –                      | –   | 15–62 months after operation, mean 48 monthst   | NR  | No differences in outcome measures and second surgeries; increasing severity of trauma was associated with more second surgeries and worse outcomes; patients with psychiatric comorbidities reported worse HRQoL              |
| Richter <i>et al</i> <sup>68</sup><br>2006<br>Germany       | Prospective monocentric cohort study   | Prevalence of PTSD; identification of risk factors for PTSD   | n=37 (76)<br>Age: mean 41.7±17.0<br>ISS: mean 30.4±10.7<br>AIS: NR<br>Injury: NR  | Days ICU stay:≥30   | –                               | –                      | –   | 7–58 months after discharge from ICU, mean 35±14 monthst                                    | Self-administered questionnaire and interview; NR   | Compared with non-trauma patients, higher risk for PTSD in trauma patients; ISS and ICU treatment not associated with PTSD   |

Continued

Table 1 Continued

| Author, year, country                                | Study design  | Objective  | Study population (number: N=(% male), age, ISS/AIS (range, mean±SD/median), kind of injury)  | Treatment   | Instrument(s) for assessment of |                        |     | Time of measurement/length of follow-up period | Results                                      |   |
|--|---|--|--|---|---------------------------------|------------------------|-----|--|--|---|
|  |   |  |  |   | QoL/HRQoL                       | (Social) Participation | ADL |  |  |   |
| Ringburg et al <sup>1</sup> 2011<br>Netherlands      | Prospective monocentric cohort study                    | HRQoL in patients after polytrauma; predictive factors for long-term poor functioning in the dimensions of HRQoL instruments | n=246 (66)<br>Age: Md 40<br>ISS: Md 22<br>AIS: NR<br>Injury: head, face, chest, abdomen, extremities   | NR  | EQ-5D, HUI 2, HUI 3             | -                      | -   | 12 months post-trauma†                         | Self-administered questionnaire sent by post | HRQoL far below general population norms; high prevalence of specific limitations with female gender and comorbidity as predictors of long-term disability  |
| Sampalis et al <sup>26</sup> 2006<br>Canada          | Retrospective multicentric cross-sectional cohort study | Functional status and QoL 12 months after injury   | n=144 (61.8)<br>Age: 18–85; mean 44.2±17.1<br>ISS: 1–49, mean 18.9±9.4<br>AIS: NR<br>Injury: head/neck, extremity, face, thorax, abdominal, burns  | Surgical and conservative<br>Days ICU stay: 0.1–11.0, mean 3.44±0.9 | SF-36, SIP                      | -                      | -   | 0.8–1.5 years, mean 1.3 years post-trauma†     | Self-administered questionnaire sent by post | Residual impairments in functional capacity and QoL 1 year after injury; specific subgroups (injuries resulting from motor vehicle collisions, thoracic and head injuries) report diminished QoL; ICU treatment, prolonged length of hospital stay and surgical treatment are predictors for poor functional capacity and reduced QoL |
| Schmidt-Rohlfing et al <sup>42</sup> 2011<br>Germany | Retrospective monocentric cohort study                  | Correlation between scoring systems focusing on QoL and those focusing on functional status of knee joint                    | Study population of the Hannover Rehab study<br>Patients with knee injury<br>n=48 (73)<br>Age: mean 29.7±11.8<br>ISS: mean 22±9.8<br>AIS: NR<br>Patients with femur fracture<br>n=107 (72)<br>Age: mean 26.8±13.9<br>ISS: mean 23.3<br>AIS: NR<br>Injury: knee, femoral fracture, head | Surgical  | HASPOC, SF-12                   | -                      | -   | Mean 16.9±4.9 years post-trauma†               | Assessment via physician, NR                 | No correlation between scoring systems for functional knee condition and QoL; poorer outcome for patients with knee injuries compared with patients with femoral fractures  |
| Simmel et al <sup>57</sup> 2013<br>Germany           | Retrospective monocentric cohort study                  | QoL and health status many years after polytrauma and influencing factors  | n=127 (76)<br>Age: mean 36<br>ISS: 26–75, mean 35.6<br>AIS: NR<br>Injury: NR   | Days ICU stay (mean): 21.1  | POLO chart                      | -                      | -   | 38–108 months post-trauma, mean 70 months†     | Self-administered questionnaire sent by post | Significantly reduced QoL and health status after polytrauma: higher age, female gender, low education and chronic previous illnesses have a negative impact on outcomes as well as difficulties with authorities/institutions, unemployment, long inpatient stays and subjectively inadequate inpatient treatment                    |

Continued

**Table 1** Continued

| Author, year, country                               | Study design                            | Objective  | Study population (number: N=(% male), age, ISS/AIS (range, mean±SD/median), kind of injury)   | Treatment  | Instrument(s) for assessment of  |                        |     | Time of measurement/length of follow-up period                                  | Application/setting  | Results |
|---|---|--|---|--|--|------------------------|-----|---|--|---------|
|   |   |  |   |  | QoL/HRQoL  | (Social) Participation | ADL |   |  |         |
| Sirois <i>et al</i> <sup>66</sup><br>2009<br>Canada | Retrospective multicentric cohort study | Regional differences in perceived need for and barriers to post-acute rehabilitation services; long-term and physical health outcomes in patients after polytrauma | n=435 (64.5) Age: 18–65, mean 41.1±15.1 ISS: 1–75 AIS: NR Injury: spine, brain, extremity   | NR   | SF-12, V.2 (PCS and subscales physical function, role general health perception) | –                      | –   | Telephone interview with patient (if necessary, with proxy)                     | No regional differences in perceived need and barriers to post-acute rehabilitation services; no regional differences in long-term functional outcomes and physical health in patients after polytrauma, with the exception of a slightly lower score in SF-12 subscale physical functioning in regions with limited availability of rehabilitation services   |         |
| Sluys <i>et al</i> <sup>68</sup><br>2005<br>Sweden  | Retrospective monocentric cohort study  | Outcome and QoL 5 years after injury and identification of factors potentially associated with outcome and QoL   | n=205 (74) Age: 20–87, Md 39 ISS: 9–87, Md 14 AIS: 3–5 Injury: extremities, pelvic girdle, head and neck, chest, external/skin, abdominal or pelvic content, face | Surgical, conservative Days ICU stay: 1–86, mean 4 | SF-36  | –                      | –   | Self-administered questionnaire sent by post, or telephone interview            | Relevant decrease in HRQoL and permanent impairments as well as disabilities in most of the affected patients; length of hospital stay, days spent on ICU, surgical procedures, in-hospital major complications, age, recurrent injury and inadequate information are risk factors for poor HRQoL; injury severity did not predict poor HRQoL  |         |
| Soberg <i>et al</i> <sup>69</sup><br>2007<br>Norway | Prospective monocentric cohort study    | Complete and partial return to work rate; prognostic factors for complete return to work after polytrauma  | n=100 (82) age: 18–67, 34.5±13.5 ISS: mean 28.1±11.3 AIS: NR Injury: head/neck, face, chest, abdomen/pelvic content, extremity, external, spinal cord             | Ventilator days (median): 5 (IQR 9)                | SF-36  | –                      | –   | Self-administered questionnaire sent by post, telephone interview of 2 patients | Complete return to work: four out of 10 patients 2 years after polytrauma, 2/3 actively attempting to return to work; lower education, low social functioning and >20 weeks in hospital or rehabilitation are risk factors for not returning to work; tententially better mental health in returnees than in non-returnees to work, overall lower mental sum scores than for general population; physical health 1 year after trauma significantly lower than for general population |         |

Continued

**Table 1** Continued

| Author, year, country                                      | Study design                           | Objective  | Study population (number: N=(% male), age, ISS/AIS (range, mean±SD/median), kind of injury)   | Treatment                 | Instrument(s) for assessment of |                        |  | Time of measurement/length of follow-up period            | Results  |
|--|--|--|---|---------------------------|---------------------------------|------------------------|--|---|--|
|  |  |  |   |                           | QoL/HRQoL                       | (Social) Participation | ADL  |   |  |
| Soberg <i>et al</i> <sup>68</sup> 2011<br>Norway           | Prospective monocentric cohort study   | Work status and trajectory of return to work after polytrauma; prognostic factors for the return to work of patients after polytrauma over 5 years | n=75 (63)<br>Age: 18–67, 34.5±13.5<br>ISS:<br>NRTW group<br>Mean 28.9±12.5<br>RTW group<br>Mean 25.8±10.8<br>AIS: NR<br>Injury: head (TBI), face, chest, abdomen/pelvic content, spinal, upper extremity, lower extremity   | NR                        | SF-36                           | -                      | -  | 20.0±9.5 weeks, 1 year, 2 years and 5 years post-trauma** | Complete return to work of 50% of patients after polytrauma over 5 years, 23% receive disability benefits; higher education, better physical, social and cognitive functioning and use of coping strategies are prognostic factors for returning to work; generally better physical and mental functioning after trauma in returnees to work than in non-returnees |
| Stulemeijer <i>et al</i> <sup>70</sup> 2006<br>Netherlands | Prospective monocentric cohort study   | Impact of additional extracranial injuries on functional outcomes and on postconcussion symptoms in patients with mild TBI                         | Isolated TBI<br>n=210 (63)<br>Age: mean 35.2±12.3<br>ISS: 1–17, mean 4.7±3.4<br>AIS (head): 1–4, mean 1.9±0.7<br>TBI and extracranial injuries<br>n=89 (74)<br>Age: mean 37.9±12.0<br>ISS: 5–41, mean 14.5±7.4<br>AIS (head): 1–5, mean 2.3±0.8<br>Control group<br>n=261 (45)<br>Age, ISS, AIS: NR<br>Injury: TBI, extremities, face, chest, abdomen, external | NR                        | -                               | -                      | SF-36 (subscales of physical and social functioning) | 6 months post-traumat                                     | Poorer functional outcomes (i.e. lower levels of physical function, lower rates of return to work and generally worse outcomes) of patients with additional extracranial injuries and mild TBI but equal level of postconcussion symptoms; greater impairment in patients after polytrauma compared with the control group with mild injuries                      |
| Suzuki <i>et al</i> <sup>70</sup> 2007<br>Japan            | Retrospective monocentric cohort study | Evaluation of long-term functional outcome of patients with unstable pelvic ring fractures and correlation with other factors                      | n=57 (49)<br>Age: 16–72, mean 42<br>ISS: 9–50, mean 24.6<br>AIS: NR<br>Injury: pelvic fracture  | Surgical and conservative | SF-36                           | -                      | -  | 24.4–107.4 months, mean 47.2 months†                      | Functional outcome was not associated with ISS, fracture location or type of fracture; neurologic injury correlated with poor functional outcome   |
| Tee <i>et al</i> <sup>73</sup> 2014<br>Australia           | Prospective monocentric cohort study   | Early predictors of suboptimal health status in patients after polytrauma with spine injuries  | n=479 (71.8)<br>Age: mean 47.5±19.1<br>ISS: Md 14<br>AIS: NR<br>Injury: TBI, spine  | NR                        | SF-12                           | -                      | -  | 1 year post-traumat                                       | Early risk factors of suboptimal physical health or QoL are tachycardia, hyperglycaemia, multiple chronic pre-existing medical comorbidities and thoracic spine injuries   |

Continued

**Table 1** Continued

| Author, year, country   | Study design   | Objective   | Study population (number: N=(% male), age, ISS/AIS (range, mean±SD/median), kind of injury)   | Treatment  | Instrument(s) for assessment of                                      |                        |     | Time of measurement/length of follow-up period  | Application/setting   | Results   |
|---|--|---|---|--|--|------------------------|-----|---|---|---|
|   |  |   |   |  | QoL/HRQoL  | Participation (Social) | ADL |   |   |   |
| Van Delft-Schreurs <i>et al</i> <sup>15</sup> 2016<br>Netherlands | Retrospective monocentric cross-sectional cohort study | Structure and psychometric properties of the Dutch SMFA questionnaire in severely injured patients  | n=173 (69)<br>Age: mean 46±19<br>ISS: Md 21<br>AIS: ≥2<br>Injury: upper and lower extremity, TBI  | NR   | SMFA, WHOQOL-BREF  | -                      | -   | 1.3–4.4 years post-traumat  | Self-administered questionnaire sent by post  | Good psychometric properties of the Dutch SMFA in severely injured people and strong correlations between the SMFA and WHOQOL-BREF. Dutch SMFA seems to be valid and useful for generating an overview of physical limitations and emotional problems |
| Victorson <i>et al</i> <sup>16</sup> 2008<br>USA                  | Mixed-method monocentric study                         | Development and validation of the injury distress index (IDI)   | n=169 (66.1)<br>Age: mean 34.5±11.1<br>ISS: NR<br>AIS: 1–5<br>Injury: lower extremity, upper extremity, burn (21%)  | Surgical, conservative   | -  | -                      | -   | Mean 8 days after admission   | Self-administered questionnaire; trauma centre  | IDI showed acceptable reliability and validity  |
| Ves <i>et al</i> <sup>7</sup> 2005<br>Netherlands                 | Prospective monocentric cohort study                   | Prevalence and determinants of disabilities and return to work after severe injury  | n=166 (81)<br>Age: M: mean 33<br>F: mean 37<br>ISS: M: mean 23<br>F: mean 23<br>AIS: ≥2<br>Injury: cranium, brain, extremities, spine, pelvis, chest, thoracic contents, abdomen, pelvic contents | NR   | EQ-5D  | -                      | -   | 12–69 months, mean/Md 41 months (3.4 years) after traumata  | Self-administered questionnaire sent by post, or telephone interview                                | Substantial impact of trauma on long-term functioning; follow-up between 12 and 24 months might be suitable for outcome assessment including quality of treatment   |
| von Ruden <i>et al</i> <sup>17</sup> 2013<br>Germany              | Retrospective monocentric cohort study                 | Prognosis, incidence, trauma mechanism, mortality, invalidity, working ability/disability and QoL in patients after polytrauma with ISS ≥50 | n=88 (77.3)<br>Age: 18–63, mean 40.3±17.4<br>ISS: mean 56.8<br>AIS: mean 1.7–4.4<br>Injury: head/brain, face, chest, abdomen, spinal cord, pelvis, upper limb, lower limb, soft tissues           | Days ICU stay (mean):<br>ISS <50: 14.4<br>ISS >50: 25.9<br>Ventilator days (mean):<br>ISS <50: 13.4<br>ISS >50: 20.3 | POLO chart   | -                      | -   | 18–78 months post-trauma, mean 3.6 years  | Self-administered questionnaire sent by post; face-to-face interview with subgroup                  | Good prognosis for severely injured people, but QoL not satisfactory mainly due to psychological problems and chronic pain; 6.5% with ISS ≥50; main cause: motorbike accident; 36% mortality rate; 57% limited working ability                        |
| Williamson <i>et al</i> <sup>14</sup> 2009<br>Australia           | Prospective multicentric cohort study                  | Predictors of moderate or severe pain 6 months after injury   | n=1290 (61)<br>Age: 14–95<br>ISS: >15<br>Injury: extremities; spinal injuries   | NR   | SF-12 (only on discharge rating of status in the week before injury) | -                      | -   | 6.1–7.1 months after trauma (Md 6.5 months); before discharge and during follow-up by telephone at home (assessment of other PROs than HRQoL) | Face-to-face interview in acute hospital before discharge and during follow-up by telephone at home | Prevalence of moderate or severe pain at follow-up was 30%; predictors of pain were educational and compensation status; preinjury pain-related disability, pain intensity at discharge   |

Continued



**Table 1** Continued

| Author, year, country                                   | Study design                           | Objective   | Study population (number: N=(% male), age, ISS/AIS (range, mean±SD/median), kind of injury)   | Treatment  | Instrument(s) for assessment of |                        |     | Time of measurement/length of follow-up period  | Application/setting  | Results |
|---|--|---|---|--|---------------------------------|------------------------|-----|---|--|---------|
|   |  |   |   |  | QoL/HRQoL                       | (Social) Participation | ADL |   |  |         |
| Wurm <i>et al</i> <sup>41</sup><br>2012<br>Germany      | Retrospective monocentric cohort study | Posttraumatic QoL in patients after polytrauma with ISS ≥50   | n=88 (77)<br>Age: mean 40.3±17.4<br>ISS: mean 56.8<br>AIS*: mean 3.9–4.4<br>Injury: thorax, TBI, abdomen, spine, lower extremity  | Days ICU stay (mean): 23<br>Ventilator days (mean): 20 | POLO chart                      | –                      | –   | Self-administered questionnaire sent by post and personal interview with subgroup                     | Good survival rate but poor post-traumatic QoL mainly due to psychological problems and chronic pain   |         |
| Zelle <i>et al</i> <sup>46</sup><br>2005<br>Germany     | Retrospective monocentric cohort study | Comparison of objective and subjective outcome of patients after polytrauma with injuries below the knee joint and injuries of the lower extremity above the knee joint | Study population of the Hannover Rehab study<br>n=389 (74)<br>Age: mean 25.4±11.7<br>ISS: mean 20.2±9.3<br>AIS: NR<br>Injury: lower extremity   | NR   | HASPOC, SF-12                   | –                      | –   | Self-administered questionnaire as well as assessment via physician; examination in the trauma centre | Significantly better objective and subjective outcomes of patients after polytrauma with injuries above the knee joint compared with injuries below the knee joint; no significant differences in the MCS of the SF-12 |         |
| Zelle <i>et al</i> <sup>46</sup><br>2005<br>Germany     | Retrospective monocentric cohort study | Comparison of long-term functional outcome after polytrauma between workers' compensation patients (WCP) and non-workers' compensation patients (N-WCP)                 | Study population of the Hannover Rehab study<br>n=637 (75)<br>Age: 3–60, mean 26.4<br>ISS: 4–54, mean 20.7±9.7<br>AIS: NR<br>WCP<br>n=233 (82.0)<br>Age: mean 29.78±12.09<br>ISS: mean 20.60±10.00<br>AIS: NR<br>N-WCP<br>n=404 (71.5)<br>Age: mean 24.56±12.12<br>ISS: mean 20.80±9.61<br>AIS: NR<br>Injury: lower extremity, head, face, upper extremity, chest, abdomen, spine, neck, skin | NR   | HASPOC, SF-12                   | –                      | –   | Self-administered questionnaire as well as assessment via physician; examination in the trauma centre | Worse subjective and objective outcomes in WCP; no significant differences in the MCS of the SF-12   |         |
| Zwingmann <i>et al</i> <sup>47</sup><br>2016<br>Germany | Retrospective monocentric cohort study | Long-term HRQoL and changes in daily life of patients after polytrauma  | n=147 (75.5)<br>Age: 6.1–82.1, mean 40±19<br>ISS: 17–59, mean 28±10.6<br>AIS: NR<br>Injury: NR  | Days ICU stay (mean): 7.8±7.5                          | EQ-5D, SF-36, TOP               | –                      | –   | NR, verbal interview and/or written questionnaire sent by post  | Impaired QoL due to pain and functional disability; association of negative socioeconomic effects and emotional repercussions  |         |

\*AIS: AIS values shown for various body regions; IQR/IR: Interquartile Range; max.: highest value.

†Numbers displayed for Overall-Characteristic of study population.

‡One measurement.

§Two measurements.

¶Three measurements.

\*\*Four measurements.

††Five measurements.

ADL, activities of daily living; AIS, Abbreviated Injury Scale; ALOS, Aachen Long-term Outcome Score; EQ-5D, European Quality of Life 5-Dimension; EQ-VAS, EQ-5D visual analogue scale; F, female; FAO, Functional Activities Questionnaire; FT, fast track; GAPS, Groningen

Activity Restriction Scale; HASPOC, Hannover Score for Polytrauma Outcome; HRQoL, health-related quality of life; HUJ2, HUJ3, Health Utility Index; ICF, International Classification of Functioning, Disability and Health; ICDH, International Classification of Impairments,

Disabilities and Handicaps; ICU, Intensive Care Unit; IDI, Injury Severity Score; KATZ, Katz Index of Activities of Daily Living; M, male; MCS, Mental Component Summary score; Mid, median; n, number; NHP, Nottingham Health Profile; NR, not reported;

NRTW, non-return to work; PCS, Physical Component Summary score; POLO chart, Polytrauma Outcome Chart; PROs, patient-reported outcomes; PTSD, post-traumatic stress disorder; QoL, quality of life; RTW, return to work; SF-12, 12-Item Short Form Health Survey; SF-36,

Short Form-36 Health Survey; SIP, Sickness Impact Profile; SMFA, Short Musculoskeletal Function Assessment; TOP, Trauma Outcome Profile; WCP, workers' compensation patients; WHOQOL-BREF, WHO Quality of Life Instrument-Short Form.

Six publications were related to the Hannover Rehab study.<sup>36 42–46</sup> Four reported the results of a polytrauma study project conducted at the University Hospital Basel, which included a subproject of a study project (EK 159/02) and a polytrauma cohort.<sup>47–50</sup> Study projects at the University Medical Centre Utrecht displayed almost identical recruitment periods and locations (Holtslag *et al.*<sup>51 52</sup> January 1999 to December 2000, Holtslag *et al.*<sup>53 54</sup> January 1999 to January 2001,<sup>53 54</sup> Holtslag *et al.*<sup>53</sup> analysed a subgroup out of n=335 participants;<sup>53</sup> Holtslag *et al.*<sup>54</sup> additionally included a group ‘Fatalities’.<sup>54</sup> Two publications<sup>55 56</sup> used the same data collection but addressed different research questions (CIHR, grants no. MOP-62873, FRSQ, grant no. 3255). The publication by Sirois *et al.*<sup>56</sup> is the original study,<sup>56</sup> the publication by Ouellet *et al.*<sup>55</sup> is a secondary analysis.<sup>55</sup> Three publications comprised patients treated at the Murnau Trauma Centre from 2000 to 2005 and recorded in the TraumaRegister DGU®.<sup>40 41 57</sup> The publication by von Rūden *et al.*<sup>40</sup> and Wurm *et al.*<sup>41</sup> reported on the same investigation of a group of severely injured patients with an ISS >50; Simmel *et al.*<sup>57</sup> analysed those patients with an ISS >25.<sup>57</sup> Soberg *et al.*<sup>58</sup> investigated the same research question as Soberg *et al.*<sup>59</sup> with a follow-up of 5 years (table 1).

More than half of the publications appeared between 2005 and 2009; the number of annual publications seems to be decreasing since 2015. Table 1 provides an overview of the included publications.

### Instruments used to assess HRQoL

In total, 15 different tools were used to assess HRQoL during follow-up after polytrauma. Of those, six were generic instruments: Short Form-36 Health Survey (SF-36, n=21, 39%),<sup>35 38 47–50 53 58–71</sup> 12-Item Short Form Health Survey (SF-12, n=12, 22%),<sup>36 37 42–46 55 56 72–74</sup> Nottingham Health Profile (n=4, 7%),<sup>47–50</sup> Sickness Impact Profile (SIP, n=4, 7%),<sup>11 51 53 68</sup> Short Musculoskeletal Function Assessment (SMFA, n=1, 2%)<sup>75</sup> and WHO Quality of Life Instrument-Short Form (WHOQOL-BREF, n=1, 2%).<sup>75</sup> In addition, four preference-based tools were applied: European Quality of Life 5-Dimension (EQ-5D, n=9, 17%),<sup>1 7 47–50 52 54 71</sup> EQ-6D (n=1, 2%),<sup>34</sup> Health Utility Index Mark 2 (HUI 2, n=1, 2%)<sup>1</sup> and HUI 3 (n=1, 2%).<sup>1</sup> Three trauma-specific instruments were used: Hannover Score for Polytrauma Outcome (HASPOC, n=6, 11%),<sup>36 42–46</sup> Trauma Outcome Profile (TOP, (n=4, 7%)<sup>47 49 50 71</sup> and Aachen Long-term Outcome Score (ALOS, n=1, 2%).<sup>47</sup> The Polytrauma Outcome Chart (POLO Chart, n=6, 11%)<sup>39–41 57 76 77</sup> was used as a modular instrument consisting of the Glasgow Outcome Profile, SF-36, EQ-5D and TOP. The International Classification of Impairments, Disabilities and Handicaps (ICIDH) was reported in one publication (n=1, 2%).<sup>78</sup> Fifteen publications combined two to five different instruments to assess HRQoL.<sup>1 36 42–50 53 68 71 75</sup>

In some publications (n=5), instruments to assess HRQoL were only used partially (e.g. solely the mental or physical part, or selected subscales of the SF-36 or SF-12,

chapter ‘Disability’ of the ICIDH).<sup>35 55 56 72 78</sup> Six publications conducted a retrospective collection of HRQoL via SF-36, SF-12, EQ-5D and TOP capturing the pretrauma status.<sup>38 47–50 74</sup>

### Instruments used to assess ADL

ADL was measured by different generic instruments: Groningen Activity Restriction Scale (GARS),<sup>53</sup> Functional Activities Questionnaire (FAQ),<sup>64</sup> Katz Index of Activities of Daily Living (KATZ ADL)<sup>64</sup> and Barthel Index (BI) (each n=1, 2%).<sup>39</sup> The SF-36 subscales of physical and social functioning (n=1, 2%)<sup>79</sup> were also used to record ADL. Two publications employed self-designed questions.<sup>7 35</sup> Most frequently (n=5), a single instrument was applied to assess ADL.<sup>7 35 39 53 79</sup>

### Instruments used to assess (social) participation

One publication reported the assessment of participation by self-designed questions covering return to sports and work.<sup>53</sup>

Table 2 displays the number of publications and the instruments used to assess HRQoL, ADL and (social) participation.

### Application of instruments

A postal survey was most often used to assess HRQoL, ADL and (social) participation (n=17).<sup>1 11 34 47–53 57 58 68 72 75 77 79</sup> Next in frequency were telephone interviews (n=5),<sup>35 37 55 56 80</sup> expert assessments (n=2),<sup>45 64</sup> face-to-face interview (n=1)<sup>81</sup> and combinations of those (n=16).<sup>7 36 38 40 41 43 44 46 59 60 66 69 71 74 82 83</sup> The research settings were: trauma centre,<sup>36 43 44 46 84</sup> outpatient clinic,<sup>62 65 78</sup> hospital,<sup>39</sup> medical centre or place of patient’s residence,<sup>64</sup> hospital and home.<sup>74</sup> In four publications, no information regarding the application of instruments was provided.<sup>42 54 67 73</sup> Relatives or proxies were reported in five publications.<sup>37 52 53 56 63</sup> While most instruments are used with several data collection methods and survey settings, the HASPOC, where reported, is only recorded in the trauma centre and is assessed by a physician in addition to the respondent.

### Measurements during follow-up

PROs mentioned above were most frequently recorded at a single time point (n=47).<sup>1 7 11 34–36 39–47 49–57 60–64 66–73 75–84</sup> Few publications reported two (n=3),<sup>48 65 74</sup> three (n=2),<sup>37 59</sup> four or five (each n=1)<sup>38 58</sup> time points of assessment.

### Duration of follow-up

Most often (n=13), a follow-up of one to one and a half year was reported.<sup>1 35 38 51–54 60 62 65 68 73 81</sup> Six publications described a follow-up period of over 10 and up to 17.5 years.<sup>36 42–46</sup> Rarely, shorter follow-up periods of 8 days<sup>84</sup> to 6 months<sup>74 79</sup> were detected.

### Further PROs assessed

Beyond HRQoL, ADL and (social) participation, assessments of further PROs were reported in the included publications. Most frequently, these comprised function,

**Table 2** Quantitative overview of instruments assessing HRQoL, ADL and (social) participation in n=54 publications

| PRO                    | Category  | Instrument  | N (%)        |
|------------------------|---|---|--------------|
| HRQoL                  | Generic instruments   | Short Form-36 Health Survey (SF-36)                     | 21 (39)      |
|                        |   | 12-Item Short Form Health Survey (SF-12)                | 12 (22)      |
|                        |   | Nottingham Health Profile (NHP)                         | 4 (7)        |
|                        |   | Sickness Impact Profile (SIP)                           | 4 (7)        |
|                        |   | Short Musculoskeletal Function Assessment (SMFA)        | 1 (2)        |
|                        |   | WHO Quality of Life Instrument-Short Form (WHOQOL-BREF) | 1 (2)        |
|                        | Preference-based instruments  | European Quality of Life 5-Dimension (EQ-5D)            | 9 (17)       |
|                        |   | EQ-6D*  | 1 (2)        |
|                        |   | Health Utility Index Mark 2 (HUI 2)                     | 1 (2)        |
|                        | Trauma-specific instruments   | Health Utility Index Mark 3 (HUI 3)                     | 1 (2)        |
|                        |   | Hannover Score for Polytrauma Outcome (HASPOC)          | 6 (11)       |
|                        |   | Trauma Outcome Profile (TOP)                            | 4 (7)        |
|                        | Modular instruments   | Aachen Long-term Outcome Score (ALOS)                   | 1 (2)        |
|                        |   | Polytrauma-Outcome-Chart (POLO Chart)                   | 6 (11)       |
| Conceptual framework   | The International Classification of Impairments, Disabilities and Handicaps (ICIDH) | 1 (2)   |              |
| ADL                    | Generic instruments   | Self-designed questions                                 | 2 (4)        |
|                        |   | Groningen Activity Restriction Scale (GARS)             | each n=1 (2) |
|                        |   | Functional Activities Questionnaire (FAQ)               |              |
|                        |   | Katz Index of Activities of Daily Living (KATZ ADL)     |              |
|                        |   | Barthel Index (BI)                                      |              |
|                        |   | SF-36 subscales physical and social functioning         |              |
| (Social) Participation |   | Self-designed questions                                 | 1 (2)        |

\*EQ-6D=EQ-5D comprising an additional question capturing a cognitive component (memory, concentration, coherence and IQ). ADL, activities of daily living; HRQoL, health-related quality of life; PRO, patient-reported outcome.

pain and mental disorders (including depression and/or depressive symptoms, anxiety and post-traumatic stress disorder (PTSD)). Only few PROs focused on social support, cognition, subjective health status and social network.

**Table 3** Quantitative overview of kind and number of further reported PROs in n=54 publications

| PRO                         | N (%)   |
|-----------------------------|---------|
| Function                    | 19 (35) |
| Mental disorder             | 16 (30) |
| Pain                        | 14 (26) |
| Social support              | 7 (13)  |
| Cognition                   | 6 (11)  |
| Subjective health status    | 3 (5)   |
| Social network              | 2 (4)   |
| Neuropsychological disorder | 1 (2)   |

PROs, patient-reported outcomes.

**Table 3** provides an overview of the kind and number of further recorded PROs.

### Critical appraisal results

The methodological quality and the risk of bias was appraised using the NICE-checklist for quantitative intervention studies,<sup>30 38 76</sup> the NICE-checklist for quantitative studies reporting correlations and associations,<sup>1 7 11 31 34-37 40-74 77-83</sup> the SIGN-checklist for diagnostic studies<sup>32 39 75</sup> and the Mixed-Method Appraisal Tool.<sup>33 84</sup>

Some methodological weaknesses were identified regarding the selection of the study population, consideration of confounders (e.g. age, sex), data analysis and presentation of results, internal validity and generalisability of study results.<sup>34 40-43 45 50 60 61 65 67 71 76-78 80 82 83</sup> While most criteria of the critical appraisal were fulfilled, a moderate risk of bias was observed.<sup>7 11 36-39 44 46-53 56 57 59 60 62 63 66 69 72-75 79 81 84</sup> A low risk of bias was observed in eight publications.<sup>1 35 54 55 58 64 68 70</sup> The results of the critical appraisal are provided in online supplemental file 4.

## DISCUSSION

### Main findings

The present systematic review identified 54 publications contributing to the research questions. A great variety was observed among all investigated aspects. HRQoL was the most frequently recorded PRO, and SF-36, SF-12 and EQ-5D were the most frequently applied instruments to assess it. Data on ADL and (social) participation were rarely reported. Most questionnaires were sent out per mail. Measurements were predominantly performed at a single time point, and the follow-up period lasted mainly between one and one and a half year. Function, mental disorders and pain were the most frequently assessed categories of the other PROs.

### Instruments for the assessment of HRQoL, ADL and (social) participation

In 48 of the included publications, HRQoL was assessed—predominantly with generic and preference-based HRQoL instruments such as SF-36, SF-12, EQ-5D and NHP. Thus, over a long period of time, results are available for the impact of polytrauma on HRQoL and its possible change over time.

Unsurprisingly, the SF-36, one of the oldest and most widely used instrument for assessing HRQoL,<sup>85</sup> is the most frequently reported instrument in publications included in this review. Along with the SF-12, SF tools accounted for 61% of all identified instruments. This result is supported by observations of other reviews conducted in the field of polytrauma.<sup>85–88</sup>

Considering the use of the different instruments assessing HRQoL by the different trauma groups, it becomes apparent that instruments are used without a clearly recognisable pattern or reason. Similarly, no pattern can be identified to explain the use of the SF-12 instead of the SF-36. No information was provided in this regard in the publications. However, it can be assumed that the reason for using the SF-12 is that it takes less time to administer than the SF-36. In 1999, an international consensus conference on evidence-based guidelines for the systematic evaluation and assessment of HRQoL after polytrauma recommended the use of modular instruments comprising generic and trauma-specific aspects.<sup>89</sup> Generic instruments have been applied continuously over a long time period, have been translated into different languages and can be applied regardless of the underlying disease. They are suitable for assessing HRQoL after polytrauma since it can affect different body regions, show different injury patterns and lead to a variety of complications. In contrast, trauma-specific instruments capture targeted relevant problems and measure the longitudinal change of HRQoL.<sup>90</sup> Despite the recommendation, the POLO Chart is the only modular instrument comprising generic and trauma-specific aspects reported in the included publications.<sup>90</sup> HASPOC, TOP and ALOS were the trauma-specific tools used. HASPOC is an instrument designed to evaluate the quality of rehabilitation. Since it comprises instruments assessing inter alia HRQoL, ADL

and function,<sup>91 92</sup> we decided to subsume it into the category 'HRQoL'.

Apart from assessing HRQoL, we were particularly interested in the measurement of ADL and social participation. Regarding the assessment of ADL, five different instruments and self-designed questions in six publications were observed in our review. (Social) participation was only reported once by Holtslag *et al*.<sup>53</sup> In summary, it was notable that ADL and (social) participation after polytrauma were seldom assessed. One reason might be that measures of HRQoL or function already include several questions related to ADL and (social) participation. Predominantly, (social) participation is researched in people with brain or spinal cord injuries. A general understanding and clear definition of the participatory construct is still missing, which might be another reason for the low reporting rates of (social) participation. It has been argued that (social) participation should be one of the main aspects in rehabilitation after polytrauma,<sup>93</sup> besides survival and function and there are a number of instruments available to assess this PRO.<sup>94–96</sup> This could also be assumed for ADL.

### Application of instruments

Most frequently, a postal questionnaire was used. Compared with personal interviews, questionnaires sent by mail are quicker and less expensive.<sup>97</sup> In addition, potential bias introduced by an interviewer is excluded. However, it is not possible to verify the person answering the questionnaire, comprehension questions cannot be clarified, the full completion of the questionnaire cannot be guaranteed and the proportion of non-responders is higher.<sup>97</sup> However, other methods of data collection like personal or telephone interviews also have limitations (e.g. influence of the interviewer on the person being interviewed),<sup>97</sup> thus all data collection methods may incorporate (different) biases. The consultation of a proxy answering the questions was rarely reported. Injuries, for example, traumatic brain injuries (TBI), may require the use of a proxy and could enable the collection of outcome data after polytrauma, despite a risk of bias.<sup>97 98</sup> The present systematic review excluded publications reporting single or mono injuries like single TBIs, which might be the reason only few publications including proxies were detected.

The retrospective assessment of the pretrauma situation helps enable a comparison of results and obtain a holistic view of the outcome after an injury. Gross *et al*<sup>48 50</sup> as well as Gross and Amsler<sup>49</sup> measured prefracture level of HRQoL over 2 years after trauma.<sup>48–50</sup> However, there are limitations to this approach: memories of the pretraumatic situation can be distorted by various circumstances, which might increase the risk of recall bias.<sup>99</sup> Large population screenings or the use of population norms might help to evaluate the pretraumatic state of HRQoL.<sup>18 47</sup> Baseline assessments should ideally be made in the first week after the event. However, this is not always possible due to the severity of the injury. Another

limitation might be that some instruments are not suitable for use in hospital. For example, changed behaviour patterns measured by the SIP can also result from the very fact of being an inpatient. Apart from HRQoL, functional recovery is also of great interest and an important factor for evaluating outcomes after a polytrauma. In comparison to HRQoL and due to better quantification, the retrospective evaluation of function is more feasible.<sup>18</sup>

Most of the included publications reported a single assessment of the PROs. However, the course of recovery cannot be derived from a single measurement. The aforementioned consensus conference recommended measurements at 3, 12 and 24 months after the event.<sup>17</sup> Other groups suggested assessments of PROs after 1, 2, 4 and 12 months<sup>100</sup> or 6 and 12 months after the injury, and beyond 12 months in case of longer rehabilitation needs.<sup>13</sup>

The most frequently reported follow-up period were one to one and a half year. Six publications conducted follow-up periods of more than 10 years.

### Further PROs assessed

Further reported PROs assessed mainly function, mental disorders and pain—outcomes that are highly affected by polytrauma. Social support, subjective health status, cognition or social network were rarely recorded. This might be explained as follows: instruments assessing HRQoL mainly capture subjective health status. While cognition is frequently affected by brain injuries, publications reporting study populations with single brain injuries were excluded from this review. Social network and social support seem to influence recovery and return to work after trauma<sup>101 102</sup> and should therefore receive more attention in future research.

### Recommendations for the assessment of PROs

The existing recommendations for the use and application of instruments—as well as time points of assessments and outcomes to be measured after polytrauma—differ substantially,<sup>13 17</sup> but there are attempts to standardise outcome measurements.<sup>18</sup> Classification systems might be helpful for a standardised assessment of PROs, facilitating the adequate selection of instruments for a specific research objective.<sup>23</sup> The internet platform PROMIS—Patient-Reported Outcomes Measurement Information System—provides research tools and is continuously updated with the latest developments and newly translated instruments.<sup>103</sup> An important step towards a standardised approach of collecting HRQoL was made in the TraumaRegister DGU® by the implementation of HRQoL assessment with the SF-12.<sup>14</sup>

Furthermore, several groups have focused on the definition of special outcome variables to be recorded as default parameters. Hoffman *et al.*<sup>20</sup> recommended the development of a ‘minimum data set’ based on the ICF.<sup>20</sup> A core outcome set relevant for the respective outcome could be defined. This procedure could guide decision-making for the collection and presentation of outcomes

in studies.<sup>22</sup> In addition, ICF linking enabling a check of which ICF components are mapped by an instrument could support the tool selection for particular research questions.<sup>16 19</sup> Other authors also support the idea of core outcome sets.<sup>21 24</sup>

### Strengths and limitations

This review was conducted thoroughly based on a registered protocol in line with the PRISMA-P quality and the PRISMA statement requirements. We provide a broad overview of instruments used for the collection of HRQoL, ADL and (social) participation, along with information on their application. In addition, this study offers an overview on further PROs reported in the context of polytrauma. First efforts to standardise the collection of PROs have been achieved to optimise comparability of outcomes, but further consistency between central players (e.g. trauma registers) is needed. Therefore, this review encourages further improvement in the assessment of PROs after polytrauma.

The present systematic review has some limitations. Selection bias can be assumed as the search was restricted by the search period and language. However, we performed backward citation tracking and saw that only a few additional articles could be included. Our study only included English and German language literature and thus does not provide an insight into published results in other languages. Therefore, it cannot be ruled out that relevant publications from low-income and middle-income countries containing local results in local languages were not included. However, we assume that scientific articles are predominantly published in English; thus, the results presented here should give a comprehensive impression related to the research questions of this systematic review.

We did not use the term ‘major trauma’. Therefore, we cannot rule out that relevant publications reporting major trauma were not included. However, major trauma seemed to be increasingly mentioned in connection with single and psychological trauma—neither of which met the inclusion criteria of our systematic review. We screened systematic reviews and meta-analyses to identify further appropriate studies and would have included publications reporting major trauma if they fulfilled the inclusion criteria of this systematic review. Still, we believe that the non-use of the term ‘major trauma’ has no impact on the results of this systematic review and the answers to the research questions.

### CONCLUSION

The present review reveals variations across study findings, which impairs the comparability of outcomes after polytrauma. To improve this situation, a more standardised approach for recording PROs should be established. First efforts have been initiated, but further alignment between the central players, such as the trauma registers, is required. Continuous collection of core outcomes

during the regeneration of people with polytrauma could create the basis for a targeted use of treatments and their adaptation to the results of the outcome measurement. Moreover, there appears to be little research on (social) participation and on further PROs like social support and social network. PROs need more attention in polytrauma-related outcome research. After all, we need to know the patients' perspectives on relevant outcomes after polytrauma so as to consider their needs when providing health services.

#### Author affiliations

<sup>1</sup>Institute for Health Services Research and Health Economics, Centre for Health and Society, Medical Faculty and University Hospital Düsseldorf, Heinrich-Heine-University Düsseldorf, Düsseldorf, Germany

<sup>2</sup>Fliedner Fachhochschule Düsseldorf, University of Applied Sciences, Düsseldorf, Germany

<sup>3</sup>Paracelsus Medical University, Institute of Nursing Science and Practice, Salzburg, Austria

<sup>4</sup>Institute for Health Services Research and Health Economics, German Diabetes Center, Leibniz Center for Diabetes Research at Heinrich-Heine-University Düsseldorf, Düsseldorf, Germany

<sup>5</sup>Cochrane Metabolic and Endocrine Disorders Group, Institute of General Practice, Faculty of Medicine, Heinrich-Heine-University Düsseldorf, Düsseldorf, Germany

<sup>6</sup>Department of Trauma, Orthopaedics and Hand Surgery, Städt. Klinikum Solingen, Solingen, Germany

<sup>7</sup>Department of Orthopaedics and Traumatology, University Hospital Düsseldorf, Düsseldorf, Germany

<sup>8</sup>AUC – Academy for Trauma Surgery GmbH, München, Germany

**Contributors** AI is the guarantor. M-IM, MR, SK, IG, SA, and AH-F developed the search strategy. MR, SK, IG, SA, KM, AH-F, MI-M, SF, JS, JW, and AI contributed to the development of the selection criteria, the risk of bias assessment strategy, and data extraction criteria. MR, SK, IG, KM, SOB, AH-F, and AI conducted the screenings. The critical appraisal was performed by MR, SK, IG, KM, and SOB. Data extraction was carried out by MR, IG, and CW. MR, SK, IG, SA, and AI drafted the manuscript. MR, SK, IG, SA, KM, SOB, AH-F, M-IM, CW, SF, JS, JW, and AI read the manuscript, provided feedback, and approved the final version.

**Funding** This work was supported by the Academy for Trauma Surgery GmbH (AUC). The funding supported the conduct of this systematic review. There is no award or grant number for this funding.

**Competing interests** JS was executive secretary of the Academy for Trauma Surgery GmbH (AUC). The authors declare that they have no competing interests.

**Patient consent for publication** Not required.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** No data are available.

**Supplemental material** This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

**Open access** This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

#### ORCID iD

Michaela Ritschel <http://orcid.org/0000-0001-8686-7956>

## REFERENCES

- Ringburg AN, Polinder S, van Ierland MCP, *et al.* Prevalence and prognostic factors of disability after major trauma. *J Trauma* 2011;70:916–22.
- Paffrath T, Lefering R, Flohé S. How to define severely injured patients?—An Injury Severity Score (ISS) based approach alone is not sufficient. *Injury* 2014;45:S64–9.
- Mörsdorf P, Becker S, Holstein J. [Quality of life after multiple trauma]. *Chirurg* 2014;85:208–14.
- Deutsche Gesellschaft für Unfallchirurgie eV. [Weißbuch Schwerverletztenversorgung], 2019. Available: <https://www.dgu-online.de/q-s/schwerverletzte/weissbuch-schwerverletztenversorgung.html>
- Sektion Notfall- & Intensivmedizin & Schwerverletztenversorgung der Deutschen Gesellschaft für Unfallchirurgie e.V. und AUC – Akademie der Unfallchirurgie GmbH. [TraumaRegister DGU® – Jahresbericht 2020], 2020. Available: [http://www.traumaregister-dgu.de/fileadmin/user\\_upload/traumaregister-dgu.de/docs/Downloads/Jahresbericht\\_2020.pdf](http://www.traumaregister-dgu.de/fileadmin/user_upload/traumaregister-dgu.de/docs/Downloads/Jahresbericht_2020.pdf)
- Pape-Köhler CIA, Simanski C, Nienaber U, *et al.* External factors and the incidence of severe trauma: time, date, season and moon. *Injury* 2014;45 Suppl 3:S93–9.
- Vles WJ, Steyerberg EW, Essink-Bot M-L, *et al.* Prevalence and determinants of disabilities and return to work after major trauma. *J Trauma* 2005;58:126–35.
- Debus F, Lefering R, Frink M, *et al.* Numbers of severely injured patients in Germany. A retrospective analysis from the DGU (German Society for trauma surgery) trauma registry. *Dtsch Arztebl Int* 2015;112:823–9.
- Hayes JA, Black NA, Jenkinson C, *et al.* Outcome measures for adult critical care: a systematic review. *Health Technol Assess* 2000;4:1–111.
- Haeusler J-MC, Tobler B, Arnet B, *et al.* Pilot study on the comprehensive economic costs of major trauma: consequential costs are well in excess of medical costs. *J Trauma* 2006;61:723–31.
- Post RB, van der Sluis CK, Ten Duis HJ. Return to work and quality of life in severely injured patients. *Disabil Rehabil* 2006;28:1399–404.
- Sittaro NA, Lohse R, Panzica M, *et al.* [Hannover-polytrauma-longterm-study HPLS]. *Versicherungsmedizin* 2007;59:20–5.
- Ardolino A, Sleat G, Willett K. Outcome measurements in major trauma—results of a consensus meeting. *Injury* 2012;43:1662–6.
- Kamp O, Pfeifer R, Ritschel M, *et al.* Polytrauma outcome: implementation of health-related quality of life assessment into the German trauma registry. *Eur J Trauma Emerg Surg* 2021;47:869–874.
- Farin E. ["Teilhabe" (social participation) of patients in health care research: relations to similar concepts and overview of assessment instruments]. *Gesundheitswesen* 2011;73:e1–11.
- Ballert CS, Hopfe M, Kus S, *et al.* Using the refined ICF linking rules to compare the content of existing instruments and assessments: a systematic review and exemplary analysis of instruments measuring participation. *Disabil Rehabil* 2019;41:584–600.
- Bouillon B, Kreder HJ, Eypasch E, *et al.* Quality of life in patients with multiple injuries—basic issues, assessment, and recommendations. *Restor Neurol Neurosci* 2002;20:125–34.
- Cameron PA, Gabbe BJ, McNeil JJ. The importance of quality of survival as an outcome measure for an integrated trauma system. *Injury* 2006;37:1178–84.
- Cieza A, Fayed N, Bickenbach J, *et al.* Refinements of the ICF linking rules to strengthen their potential for establishing comparability of health information. *Disabil Rehabil* 2019;41:547–583.
- Hoffman KP, Playford DE, Grill E, *et al.* Minimum data set to measure rehabilitation needs and health outcome after major trauma: application of an international framework. *Eur J Phys Rehabil Med* 2016;52:331–46.
- Prinsen CAC, Vohra S, Rose MR, *et al.* How to select outcome measurement instruments for outcomes included in a "Core Outcome Set" - a practical guideline. *Trials* 2016;17:449.
- Selb M, Escorpizo R, Kostanjsek N, *et al.* A guide on how to develop an international classification of functioning, disability and health core set. *Eur J Phys Rehabil Med* 2015;51:105–17.
- Valderas JM, Alonso J. Patient reported outcome measures: a model-based classification system for research and clinical practice. *Qual Life Res* 2008;17:1125–35.
- Williamson PR, Altman DG, Blazeby JM, *et al.* Developing core outcome sets for clinical trials: issues to consider. *Trials* 2012;13:132.

- 25 Moher D, Liberati A, Tetzlaff J, *et al.* Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 2009;6:e1000097.
- 26 Bullinger M. [The concept of quality of life in medicine: its history and current relevance]. *Z Evid Fortbild Qual Gesundhwes* 2014;108:97–103.
- 27 Deshpande PR, Rajan S, Sudeepthi BL, *et al.* Patient-Reported outcomes: a new era in clinical research. *Perspect Clin Res* 2011;2:137–44.
- 28 Gnass I, Ritschel M, Andrich S, *et al.* Assessment of patient-reported outcomes after polytrauma: protocol for a systematic review. *BMJ Open* 2018;8:e017571.
- 29 The Cochrane Collaboration. Cochrane Handbook for systematic reviews of interventions version 5.1.0, 2011. Available: <http://handbook.cochrane.org>
- 30 National Institute for Health and Care Excellence (NICE). Nice appendix F quality appraisal checklist – quantitative intervention studies, 2016. Available: <https://www.nice.org.uk/process/pmg4/chapter/appendix-f-quality-appraisal-checklist-quantitative-intervention-studies#notes-on-the-use-of-the-quantitative-studies-checklist>
- 31 National Institute for Health and Care Excellence (NICE). Nice appendix G quality appraisal checklist – quantitative studies reporting correlations and associations, 2016. Available: <https://www.nice.org.uk/process/pmg4/chapter/appendix-g-quality-appraisal-checklist-quantitative-studies-reporting-correlations-and>
- 32 Scottish Intercollegiate Guidelines Network (SIGN). Sign methodology checklist 5: studies of diagnostic accuracy, 2016. Available: [http://www.google.de/urls?sa=t&rct=j&q=&esrc=s&source=web&cd=4&cad=rja&uact=8&sqi=2&ved=0ahUKEwiYp9P824bVAhWlJIAKHSmKDZcQFgg7MAM&url=http%3A%2F%2Fwww.sign.ac.uk%2Fassets%2Fchecklist\\_for\\_diagnostic\\_accuracy-studies.doc&usq=AFQjCNETExuNUQoaEFhPoPXgk5uw-yXtGQ](http://www.google.de/urls?sa=t&rct=j&q=&esrc=s&source=web&cd=4&cad=rja&uact=8&sqi=2&ved=0ahUKEwiYp9P824bVAhWlJIAKHSmKDZcQFgg7MAM&url=http%3A%2F%2Fwww.sign.ac.uk%2Fassets%2Fchecklist_for_diagnostic_accuracy-studies.doc&usq=AFQjCNETExuNUQoaEFhPoPXgk5uw-yXtGQ)
- 33 Pace R, Pluye P, Bartlett G, *et al.* Testing the reliability and efficiency of the pilot mixed methods appraisal tool (MMAT) for systematic mixed studies review. *Int J Nurs Stud* 2012;49:47–53.
- 34 Gribnau AJG, van Hensbroek PB, Haverlag R, *et al.* U-Shaped sacral fractures: surgical treatment and quality of life. *Injury* 2009;40:1040–8.
- 35 McCarthy ML, Dikmen SS, Langlois JA, *et al.* Self-Reported psychosocial health among adults with traumatic brain injury. *Arch Phys Med Rehabil* 2006;87:953–61.
- 36 Zelle BA, Panzica M, Vogt MT, *et al.* Influence of workers' compensation eligibility upon functional recovery 10 to 28 years after polytrauma. *Am J Surg* 2005b;190:30–6.
- 37 Marasco S, Lee G, Summerhayes R, *et al.* Quality of life after major trauma with multiple rib fractures. *Injury* 2015;46:61–5.
- 38 Bouman AIE, Hemmen B, Evers SMAA, *et al.* Effects of an integrated 'fast track' rehabilitation service for multi-trauma patients: a non-randomized clinical trial in the Netherlands. *PLoS One* 2017;12:e0170047.
- 39 Lefering R, Tecic T, Schmidt Y, *et al.* Quality of life after multiple trauma: validation and population norm of the Polytrauma outcome (polo) chart. *Eur J Trauma Emerg Surg* 2012;38:403–15.
- 40 von Räden C, Woltmann A, Röse M, *et al.* Outcome after severe multiple trauma: a retrospective analysis. *J Trauma Manag Outcomes* 2013;7:4.
- 41 Wurm S, Röse M, von Räden C, *et al.* [Severe polytrauma with an ISS  $\geq$  50]. *Z Orthop Unfall* 2012;150:296–301.
- 42 Andruszkow H, Probst C, Grün O, *et al.* Does additional head trauma affect the long-term outcome after upper extremity trauma in multiple traumatized patients: is there an additional effect of traumatic brain injury? *Clin Orthop Relat Res* 2013;471:2899–905.
- 43 Dienstknecht T, Pfeifer R, Horst K, *et al.* The long-term clinical outcome after pelvic ring injuries. *Bone Joint J* 2013;95-B:548–53.
- 44 Probst C, Zelle B, Panzica M, *et al.* Clinical re-examination 10 or more years after polytrauma: is there a gender related difference? *J Trauma* 2010;68:706–11.
- 45 Schmidt-Rohlfing B, Pfeifer R, Kaneshige J, *et al.* Scoring systems for outcome after knee injuries. *Injury* 2011;42:271–5.
- 46 Zelle BA, Brown SR, Panzica M, *et al.* The impact of injuries below the knee joint on the long-term functional outcome following polytrauma. *Injury* 2005a;36:169–77.
- 47 Attenberger C, Amsler F, Gross T. Clinical evaluation of the trauma outcome profile (TOP) in the longer-term follow-up of polytrauma patients. *Injury* 2012;43:1566–74.
- 48 Gross T, Attenberger C, Hueglin RW, *et al.* Factors associated with reduced longer-term capacity to work in patients after polytrauma: a Swiss trauma center experience. *J Am Coll Surg* 2010;211:81–91.
- 49 Gross T, Amsler F. Prevalence and incidence of longer term pain in survivors of polytrauma. *Surgery* 2011;150:985–95.
- 50 Gross T, Schüëpp M, Attenberger C, *et al.* Outcome in polytraumatized patients with and without brain injury. *Acta Anaesthesiol Scand* 2012;56:1163–74.
- 51 Holtslag HR, Post MW, Lindeman E, *et al.* Long-term functional health status of severely injured patients. *Injury* 2007a;38:280–9.
- 52 Holtslag HR, van Beeck EF, Lindeman E, *et al.* Determinants of long-term functional consequences after major trauma. *J Trauma* 2007b;62:919–27.
- 53 Holtslag H, Buskens E, Rommers C, *et al.* Long-term outcome after lower extremity injuries in severely injured patients. *Eur J Trauma* 2006;32:365–73.
- 54 Holtslag HR, van Beeck EF, Lichtveld RA, *et al.* Individual and population burdens of major trauma in the Netherlands. *Bull World Health Organ* 2008;86:111–7.
- 55 Ouellet M-C, Sirois M-J, Lavoie A. Perceived mental health and needs for mental health services following trauma with and without brain injury. *J Rehabil Med* 2009;41:179–86.
- 56 Sirois M-J, Dionne CE, Lavoie A. Regional differences in rehabilitation needs, rehabilitation access, and physical outcomes among multiple trauma survivors. *Am J Phys Med Rehabil* 2009;88:387–98.
- 57 Simmel S, Drisch S, Haag S, *et al.* [Long-term results after multiple trauma with ISS  $\geq$  25. Outcome and predictors of quality of life]. *Chirurg* 2013;84:771–9.
- 58 Soberg HL, Roise O, Bautz-Holter E, *et al.* Returning to work after severe multiple injuries: multidimensional functioning and the trajectory from injury to work at 5 years. *J Trauma* 2011;71:425–34.
- 59 Soberg HL, Finset A, Bautz-Holter E, *et al.* Return to work after severe multiple injuries: a multidimensional approach on status 1 and 2 years postinjury. *J Trauma* 2007;62:471–81.
- 60 Abraham CM, Obremskey WT, Song Y, *et al.* Hospital delirium and psychological distress at 1 year and health-related quality of life after moderate-to-severe traumatic injury without intracranial hemorrhage. *Arch Phys Med Rehabil* 2014;95:2382–9.
- 61 Ahrberg AB, Leimcke B, Tiemann AH, *et al.* Missed foot fractures in polytrauma patients: a retrospective cohort study. *Patient Saf Surg* 2014;8:10.
- 62 Baranyi A, Leithgöb O, Kreiner B, *et al.* Relationship between posttraumatic stress disorder, quality of life, social support, and affective and dissociative status in severely injured accident victims 12 months after trauma. *Psychosomatics* 2010;51:237–47.
- 63 Burghofer K, Lackner CK, Stolpe E. [Quality of life 5 years after severe blunt trauma]. *Notf Rett Med* 2005;8:552–63.
- 64 Jackson JC, Obremskey W, Bauer R, *et al.* Long-term cognitive, emotional, and functional outcomes in trauma intensive care unit survivors without intracranial hemorrhage. *J Trauma* 2007;62:80–8.
- 65 Lippert-Grüner M, Maegele M, Haverkamp H, *et al.* Health-Related quality of life during the first year after severe brain trauma with and without polytrauma. *Brain Inj* 2007;21:451–5.
- 66 Overgaard M, Høyer CB, Christensen EF. Long-term survival and health-related quality of life 6 to 9 years after trauma. *J Trauma* 2011;71:435–41.
- 67 Renovell-Ferrer P, Bertó-Martí X, Diranzo-García J, *et al.* Functional outcome after calcaneus fractures: a comparison between polytrauma patients and isolated fractures. *Injury* 2017;48 Suppl 6:S91–6.
- 68 Sampalis JS, Liberman M, Davis L, *et al.* Functional status and quality of life in survivors of injury treated at tertiary trauma centers: what are we neglecting? *J Trauma* 2006;60:806–13.
- 69 Sluys K, Häggmark T, Iselius L. Outcome and quality of life 5 years after major trauma. *J Trauma* 2005;59:223–32.
- 70 Suzuki T, Shindo M, Soma K, *et al.* Long-term functional outcome after unstable pelvic ring fracture. *J Trauma* 2007;63:884–8.
- 71 Zwingmann J, Hagelschuer P, Langenmaier E, *et al.* Lower health-related quality of life in Polytrauma patients: long-term follow-up after over 5 years. *Medicine* 2016;95:e3515.
- 72 Archer KR, Abraham CM, Song Y, *et al.* Cognitive-behavioral determinants of pain and disability two years after traumatic injury: a cross-sectional survey study. *J Trauma Acute Care Surg* 2012;72:473–9.
- 73 Tee JW, Chan CHP, Gruen RL, *et al.* Early predictors of health-related quality of life outcomes in polytrauma patients with spine injuries: a level 1 trauma center study. *Global Spine J* 2014;4:21–32.
- 74 Williamson OD, Epi GDC, Gabbe BJ, Cameron P, *et al.* Predictors of moderate or severe pain 6 months after orthopaedic injury: a prospective cohort study. *J Orthop Trauma* 2009;23:139–44.

- 75 van Delft-Schreurs CCHM, van Son MAC, de Jongh MAC, *et al.* Psychometric properties of the Dutch short musculoskeletal function assessment (SMFA) questionnaire in severely injured patients. *Injury* 2016;47:2034–40.
- 76 Christensen MC, Banner C, Lefering R, *et al.* Quality of life after severe trauma: results from the global trauma trial with recombinant factor VII. *J Trauma* 2011;70:1524–31.
- 77 Kaske S, Lefering R, Trentzsch H, *et al.* Quality of life two years after severe trauma: a single-centre evaluation. *Injury* 2014;45 Suppl 3:S100–5.
- 78 Hladki W, Lorkowski J, Trybus M, *et al.* Quality of life as a result of multiple injury in the aspect of limitations of handicaps--social roles. *Przegl Lek* 2009;66:134–40.
- 79 Stulemeijer M, van der Werf SP, Jacobs B, *et al.* Impact of additional extracranial injuries on outcome after mild traumatic brain injury. *J Neurotrauma* 2006;23:1561–9.
- 80 Livingston DH, Tripp T, Biggs C, *et al.* A fate worse than death? long-term outcome of trauma patients admitted to the surgical intensive care unit. *J Trauma* 2009;67:341–8.
- 81 Frénisy M-C, Bénony H, Chahraoui K, *et al.* Brain injured patients versus multiple trauma patients: some neurobehavioral and psychopathological aspects. *J Trauma* 2006;60:1018–26.
- 82 Quale AJ, Schanke A-K, Frøslie KF, *et al.* Severity of injury does not have any impact on posttraumatic stress symptoms in severely injured patients. *Injury* 2009;40:498–505.
- 83 Richter JC, Waydhas C, Pajonk F-G. Incidence of posttraumatic stress disorder after prolonged surgical intensive care unit treatment. *Psychosomatics* 2006;47:223–30.
- 84 Victorson DE, Enders CK, Burnett KF, *et al.* The injury distress index: development and validation. *Arch Phys Med Rehabil* 2008;89:1893–902.
- 85 Hoffman K, Cole E, Playford ED, *et al.* Health outcome after major trauma: what are we measuring? *PLoS One* 2014;9:e103082.
- 86 Grill E, Mittrach R, Müller M. [Systematic review of measurement instruments and concepts used for functioning outcome in multiple trauma]. *Unfallchirurg* 2010;113:448–55.
- 87 Khan F, Amatya B, Hoffman K. Systematic review of multidisciplinary rehabilitation in patients with multiple trauma. *Br J Surg* 2012;99 Suppl 1:88–96.
- 88 Hofhuis JGM, Spronk PE. Health-Related quality of life and influence of age after trauma: an overview. *J Trauma Acute Care Surg* 2014;76:549–56.
- 89 Neugebauer E, Bouillon B, Bullinger M, *et al.* Quality of life after multiple trauma--summary and recommendations of the consensus conference. *Restor Neurol Neurosci* 2002;20:161–7.
- 90 Pirente N, Bouillon B, Schäfer B. A systematically developed instrument for the assessment of health-related quality of life in multiple injured patients. The Polytrauma outcome (polo) chart. *Unfallchirurg* 2002;105:413–22.
- 91 Stalp M, Koch C, Regel G, *et al.* [Development of a standardized instrument for quantitative and reproducible rehabilitation data assessment after polytrauma (HASPOC)]. *Chirurg* 2001;72:10.1007/s001040051312:312–8.
- 92 Stalp M, Koch C, Ruchholtz S, *et al.* Standardized outcome evaluation after blunt multiple injuries by scoring systems: a clinical follow-up investigation 2 years after injury. *J Trauma* 2002;52:1160–8.
- 93 Simmel S, Bühren V. [Surviving multiple trauma – what comes next?]. *Unfallchirurg* 2009;112:965–74.
- 94 Resnik L, Plow MA. Measuring participation as defined by the International classification of functioning, disability and health: an evaluation of existing measures. *Arch Phys Med Rehabil* 2009;90:856–66.
- 95 Magasi S, Post MW. A comparative review of contemporary participation measures' psychometric properties and content coverage. *Arch Phys Med Rehabil* 2010;91:S17–28.
- 96 Eyssen IC, Steultjens MP, Dekker J, *et al.* A systematic review of instruments assessing participation: challenges in defining participation. *Arch Phys Med Rehabil* 2011;92:10.1016/j.apmr.2011.01.006:983–97.
- 97 Pfaff H, Bentz J, Ommen O. Qualitative und quantitative Methoden der Datengewinnung. In: Schwartz FW, Walter U, Siegrist J, eds. *Public Health - Gesundheit und Gesundheitswesen. 3. Auflage.* München: Urban & Fischer, 2012: 451–67.
- 98 Bitzer EM. Die Perspektive der Patienten - Lebensqualität und Patientenzufriedenheit. In: Schwartz FW, Walter U, Siegrist J, eds. *Public health Gesundheit und Gesundheitswesen. 3rd edition.* München: Urban & Fischer, 2012: 485–91.
- 99 Scholten AC, Haagsma JA, Steyerberg EW, *et al.* Assessment of pre-injury health-related quality of life: a systematic review. *Popul Health Metr* 2017;15:10.
- 100 Van Beeck EF, Larsen CF, Lyons RA, *et al.* Guidelines for the conduction of follow-up studies measuring injury-related disability. *J Trauma* 2007;62:534–50.
- 101 Prang K-H, Berecki-Gisolf J, Newnam S. Recovery from musculoskeletal injury: the role of social support following a transport accident. *Health Qual Life Outcomes* 2015;13:10.1186/s12955-015-0291-8.
- 102 de Graaf MW, Reininga IHF, Heineman E, *et al.* The development and internal validation of a model to predict functional recovery after trauma. *PLoS One* 2019;14:e0213510.
- 103 PROMIS Germany. Dynamic tools to measure health outcomes from the patient perspective. Available: <http://promis-germany.de>