BMJ Open

Protocol for the mixed-methods development of a concussion-specific health-related quality of life outcome measure based on the international classification of functioning, disability and health

Jacqueline van Ierssel,[1] Heidi Sveistrup,[2] Shawn Marshall[3,4]

Check for updates

For numbered affiliations see end of article.

Correspondence to
Dr Heidi Sveistrup;
heidi.sveistrup@uottawa.ca

ABSTRACT

Introduction Recovery from concussion has traditionally been evaluated by patient-reported symptoms, objective measures such as loss of consciousness, specific dimensions such as depression or fatigue, cognitive status, employment status, level of physical activity and the more complex construct of disability. Increasingly, patient-reported outcome measures of health-related quality of life (HRQOL) are being emphasised as an important end point in patient care, clinical trial and health policy decisions. Currently, no standardised concussion-specific HRQOL outcome measure exists. The process for developing a concussion-specific HRQOL outcome measure based on the international classification of functioning, disability and health is outlined.

Methods and analysis A multistage, patient-centred approach to developing the outcome measure will integrate evidence from systematic reviews, qualitative research and cognitive interviewing into a self-report questionnaire to guide clinical decision-making. The psychometric properties of the questionnaire will be evaluated to assess the inter-rater reliability and construct validity of the measure in individuals with persistent post-concussion symptoms. To date, the systematic review and the clinical expert interviews within the preparatory phase have been completed and work is progressing on the subsequent phases. It is anticipated that the outcome measure will be ready for psychometric testing in September 2018.

Ethics and dissemination Ethical approval was granted by the Ottawa Health Science Network Research Ethics Board (Protocol #20170720-01H) on 31 October 2017 to conduct the patient and clinical expert interviews. Ethical approval for psychometric testing of the outcome measure will be sought by the Ottawa Health Science Network Research Ethics Board in Phase II, after the development of the final HRQOL questionnaire. Results will be disseminated through peer-reviewed journals and professional conferences.

PROSPERO registration Phase I systematic review registration number CRD42017075588 (15 June 2017). Phase II systematic review registration number CRD42017075588 (27 September 2017).

Strengths and limitations of this study

► This study follows the recommendations of the Food and Drug Administration for the development of patient-reported outcome measures.
► The questionnaire will be developed based on a conceptual model to identify the components of health-related quality of life post-concussion and the causal relationships between them.
► Patient contribution to item generation will maximise the content validity of the outcome measure by ensuring that the items on the questionnaire are relevant to patients with persistent post-concussion symptoms.
► Linking items on the questionnaire to the International Classification of Functioning, Disability and Health will enable content comparison of outcome measures and facilitate clinical decision-making by allowing multidisciplinary healthcare professionals to set meaningful patient-directed goals.
► Currently, no concussion-specific HRQOL outcome measure exists; therefore, there is no gold-standard measure against which to evaluate criterion validity of a newly developed questionnaire.

INTRODUCTION

Concussion represents a distinct subset of traumatic brain injury (TBI) at the milder end of severity, which falls outside the expected clinical presentation seen with moderate–severe TBI. The term concussion may be used interchangeably with mild TBI (mTBI) and is defined by The American Congress of Rehabilitation Medicine as a traumatically induced physiological disruption of brain function, as manifested by at least of the following: (1) any period of loss of consciousness; (2) any loss of memory for events immediately before or after the accident; (3) any alteration in mental state at the time of injury

BMJ

such as feeling dazed, disoriented or confused and (4) focal neurological deficit(s) which may or may not be transient.[1] The severity of the injury may not exceed the following: (1) loss of consciousness of approximately 30 min or less; (2) after 30 min, an initial Glasgow Coma Scale (GCS) of 13–15 and (3) post-traumatic amnesia not greater than 24 hours. Both the International Collaboration of Mild Traumatic Brain Injury Prognosis and the US Department of Defense differentiate mTBI from moderate-severe TBI by the absence of structural abnormalities on either CT or MRI.[2] An expert consensus panel of concussion in sport supports this assertion, stating that the acute clinical symptoms perceived following an mTBI reflect a functional disturbance rather than a structural injury.[3] Structural abnormalities seen in patients with a GCS of 13–15 (complicated mTBI) have been associated with increased disability compared with those without intracranial pathology,[4] supporting the notion that recovery from complicated mTBI is more consistent with that from moderate to severe TBI than uncomplicated mTBI (no evidence of CT abnormalities).[5]

Mild TBI may be further differentiated from moderate-severe TBI based on functional outcome. The extended GCS (GOS-E) is considered the 'gold standard' for functional outcome following TBI. Using a cut-off of 7 on the GOS-E to indicate good recovery, a longitudinal study found that less than one-quarter of mTBI patients continued to experience restrictions in work and social participation and limitations in activities of daily living at 1 year after injury. In contrast, GOS-E scores for 62% of patients with severe TBI and 48% of patients with moderate TBI indicated residual disability at 24 months, with a 'plateauing' of recovery after 12 months[6]. Moderate to severe TBI is, thus, frequently associated with functional dependence both in and outside the home and reduced work and social participation due to cognitive and physical disabilities.

Differences in structural damage, mortality rates, functional outcomes and increased rates of disability suggest that recovery from concussion should be evaluated separately from moderate to severe TBI. This paper will use the term concussion to denote mTBI without the presence of structural abnormalities on standard neurodiagnostic imaging and will focus on those patients with persistent post-concussion symptoms (PPCS), with persistent defined as 3 months or longer postinjury.

Most concussion patients are expected to make a full recovery and return to work and other preinjury activities within days to months. Although best evidence suggests that objective cognitive deficits are not measurable beyond the 3-month period of expected normal recovery post-concussion,[5] 10–15% will go on to develop PPCS, which may persist for months or years.[7] Common symptoms such as headache, fatigue and difficulty concentrating are non-specific to concussion and do not differ significantly from general trauma patients.[4] Since overall mortality and functional dependence following a concussion is rare, it is unclear whether poor outcomes can be attributed to concussion-related brain changes, pre-existing conditions or other factors.

Recovery from concussion has traditionally been evaluated by multimodal measures, such as patient-reported symptoms, objective measures such as loss of consciousness, specific dimensions such as depression or fatigue, cognitive status, employment status, level of physical activity and the more complex construct of disability. However, these measures do not fully capture the *significance* of the impairments or level of participation postinjury as experienced by the individual.

The Interagency Common Data Elements TBI Outcomes Workgroup identified health-related quality of life (HRQOL) as a core construct to be assessed, covering domains relevant to concussion; applied as either part of a comprehensive battery or in addition to other outcome measures.[8] The International Society for Quality of Life Research defines HRQOL as 'the functional effect of a medical condition and/or its consequent therapy on a patient'.[9] HRQOL is often erroneously inferred from other measures of health, such as symptoms, functioning or health status. Symptoms represent a patient's perception of an abnormal physical, emotional or cognitive state.[10] Functioning is defined by the International Classification of Functioning, Disability and Health (ICF) as 'an umbrella term encompassing all body functions, activities and participation'.[11] Whereas the WHO describes health as 'a state of complete physical, mental and social well-being not merely the absence of disease'.[12] When seen from a negative perspective, impairments in body function, activity limitations of the individual and participation restrictions at a societal level are described as disability.[11] While the above measures of health may influence a patient's HRQOL, they do not represent it. What distinguishes HRQOL is the patient's perception of the relative importance of these measures, their own values and their preferences.[13] Although HRQOL is intuitively understood, it must be explicitly distinguished from other related terms, as they represent distinct constructs. Generic HRQOL outcome measures incorporate items across multiple domains to capture a broad spectrum of issues, allowing comparison between populations and various disease states. However, generic measures, such as the WHO quality of life-brief (WHOQOL-BREF) may be insensitive to small, but clinically relevant changes to concepts important to a concussion population, such as persistent problems with cognitive functioning, or social isolation.

Condition-specific HRQOL outcome measures on the other hand, have the advantage of exploring specific health concerns in depth by incorporating items most relevant to a specific patient group and are therefore more sensitive to clinical changes that occur within those individuals.[14] Currently, no standardised concussion-specific HRQOL outcome measure exists.

It has been suggested that the ICF provides an ideal base for the development of new outcome measures in individuals with TBI.[15] Adopted by the WHO in 2001, the
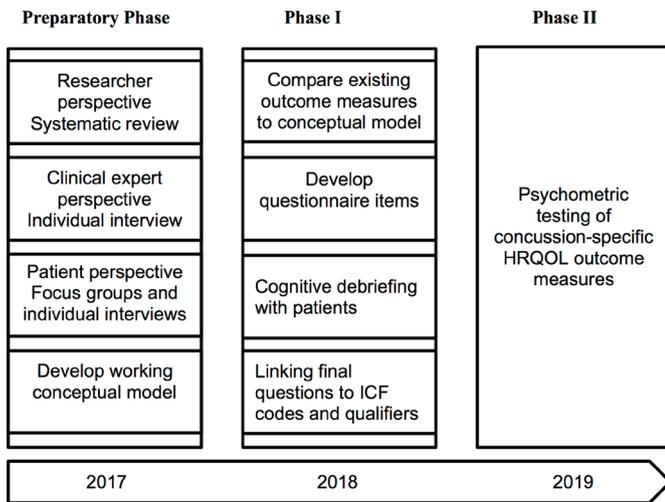
Figure 1 Mixed-method development process of a concussion-specific health-related quality of life (HRQOL) outcome measure based on the International Classification of Functioning for a multistage project started in 2017, with a projected completion date of 2019. The preparatory phase describes the development of a conceptual model of HRQOL; phase I describes the development of a HRQOL questionnaire based on the conceptual model; phase II refers to the assessment of questionnaire's test–retest reliability and construct validity with the WHO quality of life-brief and quality of life after brain injury in a concussion population. Embedded boxes within each phase represent the distinct steps required to complete each phase in successive order.

ICF serves as a universally accepted reference system to classify functioning and disability.[16] Using a biopsychosocial model, the ICF provides a standard language and a conceptual basis to describe health.[17] Both comprehensive and brief ICF core sets for TBI have been developed as a means of describing concepts most relevant to the health of an individual after TBI.[15] Questionnaires are constructed of items that measure an intended concept, such as headache. For example, headache is a common post-concussion concept measured by the item 'Headache' on the symptom evaluation scale of the Sport Concussion Assessment Tool-5[18] and by the broader item 'How often do you suffer (physical) pain?' on the WHOQOL-100.[19] This relationship enables the mapping of concepts to ICF categories.[15] Linking newly developed questionnaire items to ICF categories would enable the comparison of the content of various outcome measures and facilitate communication between multidisciplinary healthcare providers by providing a common language with which to describe function, disability and health.

Persistent post-concussion symptoms significantly impact a broad set of concepts that span across all domains of the ICF. These concepts then influence HRQOL. Measuring HRQOL as a construct determined by these concepts makes conceptual sense in a TBI population, since there is often no relationship between these causal indicators.[20] The purpose of this paper is, thus, to present the steps in the development of a concussion-specific HRQOL outcome measure based on the ICF

(figure 1). The construct of HRQOL will be measured as a reflection of multidimensional concepts. In keeping with patient-centred outcomes research, the process is patient driven and consists of multiple phases.

METHODS
Patient and public involvement
Patient involvement will be a keystone in the development of a concussion-specific questionnaire. Within the overarching construct of quality of life, patients will be specifically asked to identify those issues that are greatest importance to them and what issues they would like addressed in a questionnaire based on their lived experience with PPCS. Additionally, their input is being sought in the design of the questionnaire formatting. Clinician input will also be sought to identify issues that may have relevance to patients with PPCS. This will be an iterative process, such that patient preferences and clinician feedback will be reviewed in subsequent discussions to ensure that the views of the patients and clinicians are well represented in the questionnaire. Finally, the working questionnaire will be brought back to a sample of patients to confirm that their priorities and preferences have been adequately captured. On completion of the study, patients and clinicians who have participated in the study will be provided with an electronic copy of the final questionnaire.

The development of a concussion-specific HRQOL outcome measure involves three distinct phases: a preparatory phase, phase I and phase II. The preparatory phase involves the development of a conceptual model, which will form the framework for the concepts to be included in the questionnaire. In phase I, the identified concepts will be transformed into a concussion-specific HRQOL questionnaire. Phase II involves the psychometric testing of the questionnaire in patients with PPCS.

Preparatory phase—development of a conceptual model
Within the preparatory phase, a systematic review has already been performed to develop a *working* conceptual model consisting of broad domains that have been linked to the ICF. Qualitative interviews with clinicians and patient focus groups will identify the specific concepts within each domain that are impacted by concussion in order to further develop and refine the working conceptual model. The *final* conceptual model will be developed through content analysis of the qualitative data.

Researcher perspective: systematic review
A systematic review was undertaken to identify the HRQOL outcome measures used in concussion-specific research since the introduction of the International Classification of Diseases, Tenth Edition code for concussion in 1992. The specific objectives of the review were (1) to identify the concepts contained in the measures using the ICF as a reference,[21 22] (2) to describe the breadth and depth of concepts and (3) to develop a working conceptual model

of HRQOL in individuals with PPCS based on the concepts identified. Eight electronic databases were searched from 1 January 1992 to 12 March 2017, including Medline (OVID), Embase (OVID), PsycINFO (OVID), Cumulative Index to Nursing and Allied Health Literature (CINAHL) (EBSCO), SCOPUS, the Cochrane Database for Systematic Reviews, Prospero and Patient-Reported Outcome and Quality of Life Database (PROQOLID; http://www.qolid.org). Grey literature was searched, reference lists scanned and relevant journals hand-searched. Search terms included database subject headings and keywords for the concepts: 'concussion', 'traumatic brain injury' and 'quality of life' using a Boolean strategy and adapted for each database.

Studies were eligible if they involved primary qualitative or quantitative research exploring the impact of PPCS on HRQOL in adults aged 18–65 years with a diagnosis of concussion. Studies were excluded if they included the results of a moderate–severe TBI sample not differentiated from the concussion sample or patients presented with evidence of structural injury or intracranial bleeding on diagnostic imaging.

Content analysis was performed on individual questions within identified outcome measures by linking concepts to second level ICF categories according to established linkage rules.[21 23] Concepts were then organised into domains at the ICF component level. A working conceptual model of HRQOL post-concussion was proposed based on these results to inform the content of semistructured interviews with clinicians and patient focus groups. This systematic review has been registered with PROSPERO (CRD42017068241).

Clinician perspective: individual interviews

The importance of clinician interviews in the development of an HRQOL outcome measure is twofold. First, clinicians will improve content validity by identifying clinically important domains that should be considered in the conceptual model. Additionally, clinicians in this study will be asked to identify perceived facilitators and barriers to the use of a concussion-specific HRQOL outcome measure in their clinical practice.

Clinicians will be purposively sampled to represent the diverse healthcare provider groups who treat the key domains from which PPCS are comprised. Eligibility includes a minimum of 3 years of clinical experience working with concussion patients and will include at least one representative from each of the following groups: physicians, neuropsychologists, physiotherapists, occupational therapists, neuro-optometrists and speech-language pathologists. These clinicians will be chosen based on their recognition as national experts in the management of post-concussion symptoms, as evidenced by their membership in national concussion guidelines working groups. Written informed consent is required prior to participation.

Concepts perceived by clinicians to have an impact on the HRQOL of patients with PPCS will be identified through semistructured interviews and linked to second level ICF categories. Feedback from clinicians on the use

of an HRQOL outcome measure will be incorporated into the design of the questionnaire to facilitate the implementation of the final questionnaire in clinical practice.

Patient perspective: focus groups

A comprehensive list of HRQOL concepts that are relevant to patients with PPCS will be collected using focus groups and linked to second level ICF categories using content analysis.

Patients will be recruited from the Acquired Brain Injury Outpatient Clinic at the Ottawa Hospital Rehabilitation Centre and from community-based medical clinics throughout Ottawa with known concussion management programmes.

Patients will be considered eligible for inclusion if they are English speakers between the ages of 18 and 65 years and have experienced persistent symptoms for at least 3 months following a diagnosed concussion sustained between 2008 and 2018. Patients will be excluded if they have a diagnosis of moderate-severe TBI, if they were receiving treatment for a pre-existing mental health disorder or addiction at the time of injury or if there is evidence of post-traumatic structural injury or intracranial bleeding on diagnostic imaging, if available. Written informed consent is required from all patients prior to participating in the study.

We estimate that a minimum of 30 patients will be sufficient to reach data saturation. The patient perspective will be used to expand on and refine the working conceptual model and identify the most relevant emerging concepts.

Patients will be asked to identify how their concussion has impacted their HRQOL through open-ended questions and review of existing questionnaires, guided by the working conceptual model. Concepts derived from patient focus group discussions will be extracted using content analysis and linked to second level ICF categories. Concepts will then be deductively coded into the domains of the working conceptual model. An inductive approach will also be used to add additional domains as needed to reflect emerging concepts from the data. Data collection and linking will be conducted iteratively during multiple rounds of focus group discussions so that patients in subsequent groups can confirm the relevance and importance of concepts that have emerged from earlier discussions. Two independent researchers will review the domains established through coding to agree on the final conceptual model. Discrepancies will be resolved through discussion with a third researcher.

Intercoder reliability between the researchers will be determined by using the kappa statistic for inter-rater reliability on a select sample of transcripts. A kappa of >0.7 will be considered acceptable for intercoder reliability.

Phase I development of a concussion-specific HRQOL questionnaire
Systematic review

A systematic review will be conducted to determine if existing generic and TBI-specific HRQOL outcome

measures possess sufficient content validity to evaluate outcomes in concussion research. The specific objectives of the review are: (1) to identify existing generic and TBI-specific outcome measures currently being used to evaluate HRQOL in patients post-concussion; (2) to compare the content of existing outcome measures with the concussion-specific conceptual model of HRQOL and (3) to assess whether questions in existing measures reflect domains in the conceptual model (content relevance) and whether all the domains in the conceptual model are represented appropriately (content representativeness) by questions in the identified measures. It is hypothesised that existing HRQOL outcome measures contain both questions that are relevant to concussion patients, such as cognitive abilities, and questions not identified by patients as relevant to their HRQOL post-concussion, such as satisfaction with bodily appearance. More importantly, it is hypothesised that some concussion-specific domains identified by the conceptual model will be under-represented or absent from existing questionnaires, such as social isolation, sense of identity, uncertainty of prognosis or the stigma of an invisible injury.

Eight electronic databases will be searched from 1 January 1992 onwards, including Medline (OVID), Embase (OVID), PsycINFO (OVID), Cumulative Index to Nursing and Allied Health Literature (CINAHL) (EBSCO), SCOPUS, the Cochrane Database for Systematic Reviews, Prospero and Patient-Reported Outcome and Quality of Life Database (PROQOLID; http://www.qolid.org). Grey literature will be searched, reference lists scanned and relevant journals hand-searched. Search terms will include database subject headings and keywords for the concepts: 'concussion', 'traumatic brain injury', and 'quality of life' using a Boolean strategy and adapted for each database.

Studies will be included if they assess self-reported HRQOL in adults aged 18–65 years with persistent symptoms 1 month or more following a diagnosed concussion. Studies using proxy measures, single-item rating scales or involving concussion sustained in conjunction with multiple trauma will be excluded.

Specific questions from existing outcome measures will be linked to second level ICF categories to facilitate content comparison between existing outcome measures and the concussion-specific conceptual model.[16] This will provide a comprehensive understanding of the conceptual basis of what is being measured by each of the outcome measures and identify any potential gaps in assessment tools. Content validity will be assessed with respect to content relevance and representativeness. Within each outcome measure, individual questions will be considered to possess content relevance if they can be linked to second level ICF categories of the concussion-specific conceptual model. Content representativeness will be assessed to determine the extent to which the relevant domains within each outcome measure may be over-represented, under-represented or excluded.

If the balance is wrong, the outcome measure will lack content validity. Consistent with the previous studies, existing HRQOL outcome measures will be considered to possess acceptable content validity if 75% or more of the questions demonstrate both content relevance and content representativeness.[24] Psychometric properties, including reliability, and responsiveness in a concussion population will be extracted and analysed from published reports for any existing measures that meet the above criteria. Outcome measures will be considered suitable for use in a concussion population if they demonstrate a minimum threshold of a kappa statistic of 0.7 for intra-rater reliability, and at least a moderate effect size of 0.5 for responsiveness, to indicate the ability to measure clinically important change in patients with PPCS.[25 26] Support for a new concussion-specific HRQOL outcome measure will be established if existing outcome measures do not meet the above criteria.

This systematic review has been registered with PROSPERO (CRD42017075588).

Pilot-questionnaire development

Concepts from the final conceptual model will be transformed from second level ICF codes into a comprehensive list of subjective questions for a pilot concussion-specific HRQOL outcome measure, hereafter referred to as the CONcussion quality of life (CONQOL). The CONQOL will be constructed as a self-administered questionnaire that evaluates the *impact* of each concept on HRQOL, as opposed to how *satisfied* or *bothered* a patient is by the concept identified in the question; for example, 'How much does the stigma of an invisible injury impact your health-related quality of life?'. Framing the questions from the perspective of how much each concept *impacts* HRQOL more directly measures the extent of the problem; whereas HRQOL questions traditionally framed as satisfaction or bother may be confusing for patients to disentangle the magnitude of functional limitations or activity restrictions from their ability to cope with the problem.

Patients will be asked to quantify the magnitude of time or severity of each concept within the past week. This interval was chosen to minimise the risk of recall bias and respondent burden, while balancing sufficient time for the participant to provide a reliable estimate of the impact of PPCS on their HRQOL. Additionally, the persistent nature of PPCS makes natural healing effects unlikely within the specified timeline. The magnitude or severity of each question will be rated on a five-point Likert scale with both descriptive and numerical anchor points for each response (0=No problem 0%–4%; 1=MILD problem 5%–24%; 2=MODERATE problem 25%–49%; 3=SEVERE problem 50%–95% and 4=COMPLETE problem 96%–100%) consistent with the generic qualifiers used to classify ICF codes (see table 1).[11]

Respondents will then be required to rank the top three concerns identified on the questionnaire. Finally, the CONQOL will enable the respondent to identify in an

Table 1 Proposed response scale consistent with the ICF qualifiers

Response options	Descriptor	Scaling
0	No problem	0%–4% of the time
1	Mild problem	5%–24% of the time
2	Moderate problem	25%–49% of the time
3	Severe problem	50%–95% of the time
4	Complete problem	96%–100% of the time

Adapted from ICF, by WHO (2001).
ICF, International Classification of Functioning, Disability and Health.

open-ended qualitative format up to three goals they wish to accomplish with treatment that would have a positive impact on their HRQOL. For each goal, the respondent will be prompted to rate both how important the goal is and to what extent they have achieved it on a 10-point Likert scale (1=not at all; 10=extremely/completely). The addition of patient-reported goals is intended to facilitate clinician–patient communication and identify priorities for interventions. The CONQOL will be scored as an index, with scores generated for each subdomain, and an overall summative score. Each subdomain will be grouped to represent functional domains identified in standardised concussion guidelines, such as cognitive, emotional and vestibular domains, where appropriate. Grouping questions by functional domains will allow clinicians to identify areas that need to be assessed in more detail through further probing of symptoms and standardised outcome measures. This will streamline the clinical assessment based on those domains that have the greatest impact on the patients' HRQOL.

Finally, the CONQOL will include a section that prompts clinicians to provide patients with relevant concussion-specific resources, such as external organisations that provide educational modules, websites, informative handouts and standardised guidelines. Thus, the CONQOL will function to evaluate HRQOL, guide clinical decision-making and provide patient education.

Cognitive interviewing
The CONQOL will then be pretested using face-to-face cognitive interviewing to identify any problems with the questionnaire items, formatting or administration. The purpose is to ensure patient understanding, appropriateness of response options and recall period, level of readability and completeness of the concepts contained in the questions.[27 28] This process is necessary to improve the design of the CONQOL by informing revision decisions and providing evidence of content validity. Cognitive interviews will be performed using the 'think-aloud' technique to describe the patients' thought process as they read each question, followed by 'verbal probing' if necessary to clarify any sources of confusion.[29]

This process will be an iterative approach with multiple rounds of interviewing and item revision. Consistent with published recommendations, a minimum sample size of 15 will be sought to increase the probability of detecting problems with the pilot questionnaire.[29] Initial interviews will explore major conceptual problems and global issues with the CONQOL, with an emphasis on conceptual clarity, content coverage and respondent burden. Subsequent interviews will focus on structural or logical problems with the CONQOL such as unclear wording, grouping of questions, formatting issues and appropriateness of questions. Varying perspectives will be elicited by selecting patients across a broad representation of demographics, mechanism of injury, previous history of concussion, employment characteristics and time since injury. Written informed consent will be obtained.

Questionnaire refinement
Following each round of interviewing, the questionnaire development team will identify problems on an item-by-item basis using the Question Appraisal System-99.[30] Similar to the qualitative research approach to identify issues of importance during the item generation phase, problems with content or construction will be extracted and coded. The questionnaire development team will discuss and resolve identified problems after each round of interviews. Consensus will be required in order to retain, revise, delete or add additional questions or make structural changes to the questionnaire. Careful attention will be paid to ensure that questions pertaining to each domain of the conceptual model are retained.

Phase II psychometric testing
Psychometric testing in phase II will involve a cross-sectional multicentre study to assess the test–retest reliability and construct validity of the CONQOL. Eligibility criteria for patient recruitment will be consistent with those used for during the qualitative phase of item development.

Test–retest reliablity
The CONQOL will be assessed for test–retest reliability at two time points, separated by 2 weeks. Based on clinical experience and the chronicity of PPCS, a 2-week repeat-measures study is an appropriate timeframe to minimise changes in HRQOL due to either recall bias or physiological recovery. Sample size will be calculated to be able to estimate test–retest correlations with a 95% CI (±0.1) and will follow the recommendation of 5–10 subjects per question on a newly developed outcome measure.[31] The minimum requirement for test–retest reliability will be set at a kappa statistic of ≥0.7.

Internal consistency
Outcome measures that assess a single construct, such as anxiety, contain questions that reflect the effect of the construct.[32] Because these *effect indicators* are correlated, the outcome measure is assumed to have a high degree of internal consistency.[32] The theoretical

nature of HRQOL is such that it may be influenced by many different unrelated concepts. These concepts, called *causal indicators*, are responsible for causing changes in HRQOL, rather than HRQOL affecting the concepts.[32] Correlations between causal indicators may be deliberately low in order for questions to represent a broad set of concepts. For example, if patients with PPCS experience a reduction in their post-traumatic headaches because of a new medication, their HRQOL will improve, even though there has been no change in their exercise tolerance, speed of thinking, level of fatigue or return to work status. Because a patient can endorse one concept (eg, improvement in headache) without implying that they would necessarily endorse another (eg, level of fatigue), the concepts would not be expected to necessarily correlate with each other. Therefore, it would be inappropriate to use statistics based on the assumption of homogeneity, such as internal consistency, interitem correlations or factor analysis to assess the construct of HRQOL, as this might lead to false assumptions about reliability or usefulness of the CONQOL.[32] Therefore, concepts will be allocated to subdomains based on their classification according to ICF chapters. This highlights the importance of significant input from patients with PPCS in the development of the questionnaire in order to ensure a high level of content validation.

Content validation

Evidence for the extent to which the CONQOL measures the important concepts of HRQOL in patients with PPCS will be provided through the rigorous development of the questionnaire based on a concussion-specific conceptual model. Cognitive interviewing with patients will then further confirm evidence of content validation by demonstrating that the questions influence HRQOL, no important concepts were missed and the response options, recall period and questionnaire design are appropriate, comprehensive and understandable.[33] This will ensure that each question on the CONQOL relates to one of the domains of the conceptual model (content relevance) and that each domain of the conceptual model is represented with appropriate importance by at least one question (content representativeness).

Construct validation

Construct validation of the CONQOL will be performed against the generic measure WHOQOL-BREF and the TBI-specific measure Quality of Life after Brain Injury (QOLIBRI) to provide support that the CONQOL measures what it intends to measure. It is hypothesised that the CONQOL will demonstrate moderate to high correlations with these existing measures that evaluate the same construct of HRQOL. Spearman's rank correlation will be used to assess the strength of association between similar subdomains on the outcome measures.

Criterion validation

HRQOL is an unobservable construct that cannot be measured directly. It can only be inferred by how well questions on an outcome measure fit the underlying theory. Since there is no 'gold standard' against which a newly developed HRQOL outcome measure can be compared, testing for criterion validation is not applicable.

Significance of study

The strength of the CONQOL to evaluate change in patients with PPCS will be evidenced by the substantial patient input in the development of the outcome measure, thus providing support for a high level of content validation. This concussion-specific HRQOL outcome measure would meet the specific needs of patients with PPCS by prompting clinicians to ask relevant probing questions, identify concerns, perform appropriate standardised tests, set meaningful patient-directed intervention goals, facilitate referrals to specialists and evaluate change.

The proposed design of the CONQOL to provide clinicians with recommendations for a more focused assessment and educational resources that match patient-identified problems would be a novel use of an HRQOL outcome measure to facilitate patient-centred care.

ETHICS AND DISSEMINATION

No personal health information will be collected during this research, and no personal identifying information will be accessed from records or databases. Only names, telephone number and emails of participants will be available to the research team for the purpose of screening for eligibility and scheduling. Written informed consent will be obtained from all participants prior to taking part in the study. Participants will be assigned a respondent number, and data collected will be de-identified. Data will be processed anonymously and presented as aggregate results.

Within the preparatory phase, no ethical approval is required to perform either systematic review or to develop the pilot questionnaire. Ethical approval was granted by the Ottawa Health Science Network Research Ethics Board (Protocol #20170720–01 hour) on 31 October 2017 to conduct the patient and clinical expert interviews. Ethical approval for psychometric testing of the outcome measure will be sought by the Ottawa Health Science Network Research Ethics Board in Phase II, after the development of the final HRQOL questionnaire.

The results of this project will be distributed to professional groups through peer-reviewed publications and presentations. Additionally, the results of the study will be disseminated to clinicians at conferences and strategic meetings.

REFERENCES

1. American Congress of Rehabilitation Medicine. Definition of mild traumatic brain injury. *J Head Trauma Rehabil* 1993;8:86–7.
2. Kristman VL, Borg J, Godbolt AK, *et al*. Methodological issues and research recommendations for prognosis after mild traumatic brain injury: results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. *Arch Phys Med Rehabil* 2014;95:S265–S277.
3. McCrory P, Meeuwisse WH, Aubry M, *et al*. Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012. *Br J Sports Med* 2013;47:250–8.
4. Levin HS, Diaz-Arrastia RR. Diagnosis, prognosis, and clinical management of mild traumatic brain injury. *Lancet Neurol* 2015;14:506–17.
5. Carroll LJ, Cassidy JD, Cancelliere C, *et al*. Systematic review of the prognosis after mild traumatic brain injury in adults: cognitive, psychiatric, and mortality outcomes: results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. *Arch Phys Med Rehabil* 2014;95:S152–S173.
6. Sandhaug M, Andelic N, Langhammer B, *et al*. Functional level during the first 2 years after moderate and severe traumatic brain injury. *Brain Inj* 2015;29:1431–8.
7. Ontario Neurotrauma Foundation. *Guidelines for concussion/mTBI & persistent symptoms: Second Edition*. Toronto, 2013.
8. Wilde EA, Whiteneck GG, Bogner J, *et al*. Recommendations for the use of common outcome measures in traumatic brain injury research. *Arch Phys Med Rehabil* 2010;91:1650–60.
9. *International Society for Quality of Life Research*. Health-Related Quality of Life Research. http://www.isoqol.org/about-isoqol/what-is-health-related-quality-of-life-research.
10. Anderson KL, Burckhardt CS. Conceptualization and measurement of quality of life as an outcome variable for health care intervention and research. *J Adv Nurs* 1999;29:298–306.
11. World Health Organization. *International classification of functioning, disability and health: ICF*: World Health Organization, 2001.
12. World Health Organization. WHOQOL: measuring quality of life. http://www.who.int/healthinfo/survey/whoqol-qualityoflife/en/ (accessed 9 Apr 2018).
13. Gill TM, Feinstein AR. A critical appraisal of the quality of quality-of-life measurements. *JAMA* 1994;272:619–26.
14. von Steinbuechel N, Covic A, Polinder S, *et al*. Assessment of health-related quality of life after TBI: comparison of a Disease-Specific (QOLIBRI) with a Generic (SF-36) Instrument. *Behav Neurol* 2016;2016:1–14.
15. Bernabeu M, Laxe S, Lopez R, *et al*. Developing core sets for persons with traumatic brain injury based on the international classification of functioning, disability, and health. *Neurorehabil Neural Repair* 2009;23:464–7.
16. Laxe S, Tschiesner U, Zasler N, *et al*. What domains of the International Classification of Functioning, Disability and Health are covered by the most commonly used measurement instruments in traumatic brain injury research? *Clin Neurol Neurosurg* 2012;114:645–50.
17. World Health Organization. *How to use the ICF: a practical manual for using the International Classification of Functioning, Disability and Health (ICF*, 2013.
18. Echemendia RJ, Meeuwisse W, McCrory P, *et al*. The sport concussion assessment tool 5th edition (SCAT5). *Br J Sports Med* 2017.
19. Kean J, Malec JF. Towards a better measure of brain injury outcome: new measures or a new metric? *Arch Phys Med Rehabil* 2014;95:1225–8.
20. World Health Organization. *Programme on mental health: WHOQOL user manual*: World Health Organization, 1998.
21. 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* 2016;828810:1–10.
22. Cieza A, Brockow T, Ewert T, *et al*. Linking health-status measurements to the international classification of functioning, disability and health. *J Rehabil Med* 2002;34:205–10.
23. Cieza A, Geyh S, Chatterji S, *et al*. ICF linking rules: an update based on lessons learned. *J Rehabil Med* 2005;37:212–8.
24. Gorecki C, Nixon J, Lamping DL, *et al*. Patient-reported outcome measures for chronic wounds with particular reference to pressure ulcer research: a systematic review. *Int J Nurs Stud* 2014;51:157–65.
25. Frost MH, Reeve BB, Liepa AM, *et al*. What is sufficient evidence for the reliability and validity of patient-reported outcome measures? *Value Health* 2007;10(Suppl 2):S94–S105.
26. Streiner DL, Norman GR, Cairney J. Health measurement scales: a practical guide to their development and use. *Oxford University Press, USA* 2015.
27. Food US, Administration D. Guidance for industry: patient-reported outcome measures: use in medical product development to support labeling claims. 2009. *Federal Registry* 2009.
28. Gorecki C, Lamping DL, Nixon J, *et al*. Applying mixed methods to pretest the Pressure Ulcer Quality of Life (PU-QOL) instrument. *Qual Life Res* 2012;21:441–51.
29. Peterson CH, Peterson NA, Powell KG. Cognitive interviewing for item development: validity evidence based on content and response processes. *Measurement and Evaluation in Counseling and Development* 2017;50:217–23.
30. Willis GB, Lessler JT. *Question Appraisal System - QAS-99*, 1999.
31. Gorecki C, Brown JM, Cano S, *et al*. Development and validation of a new patient-reported outcome measure for patients with pressure ulcers: the PU-QOL instrument. *Health Qual Life Outcomes* 2013;11:95.
32. Streiner DL. Being inconsistent about consistency: when coefficient alpha does and doesn't matter. *J Pers Assess* 2003;80:217–22.
33. Patrick DL, Burke LB, Gwaltney CJ, *et al*. Content validity – establishing and reporting the evidence in newly developed patient-reported outcomes (PRO) instruments for medical product evaluation: ISPOR PRO Good Research Practices Task Force report: part 2--assessing respondent understanding. *Value Health* 2011;14:978–88.