Understanding and measuring behavior after TBI (see Figure 1 developed and initially validated to provide a foundation for reproducing from JCEN) [1]. As illustrated in the model, behavioral disruptions after TBI manifest from the interactions between emotional changes, frequently leading to disrupted behaviors. It is not surprising, then, that traumatic brain injury (TBI), which triggers unique emotional changes, frequently results in cognitive and behavioral changes in biological processes and often results in cognitive and emotional changes, frequently leading to disrupted behaviors. It is also not surprising that behavior is particularly challenging to operationalize and therefore to effectively measure after TBI. However, effectively assessing behavioral disruptions is critical for the provision of appropriate and effective interventions, as behavior is known to be one of the greatest contributing factors to poor outcomes – both acutely and chronically – after injury [1,3–5].

The conceptual model of behavior in Figure 1 was previously developed and initially validated to provide a foundation for understanding and measuring behavior after TBI (see Figure 1 – reproduced from JCEN) [1]. As illustrated in the model, behavioral disruptions after TBI manifest from the interactions between emotional and cognitive changes after injury and are context-dependent, involving both personal and environmental factors.

This mirrors the conceptualization of disability proposed by the World Health Organization’s (WHO) International Classification of Functioning, Disability, and Health (ICF) [6], a comprehensive taxonomy used to classify and describe health and health-related domains [7]. The framework, endorsed by the WHO in 2001, and its children and youth (CY) version in 2007 [7], is composed of four distinct components that are further broken down into chapters and categories. A set of standardized linking rules developed in 2002, updated in 2005, and further refined in 2016, provides the ability to systematically explore and evaluate the content of assessments used to collect health-related data by linking health concepts in these assessments to the ICF. This technique has been used extensively to examine the content of assessment tools from a variety of disciplines [8,9]. The WHO’s ICF Research Branch also employs these linking rules as part of the standardized iterative process used to define ICF Core Sets. A Core Set is a set of ICF categories used as a basic standard to describe, evaluate, and research the functioning and disability of individuals with specific diagnoses [10]. Since 2002, ICF Core Sets have been developed for over 34 health conditions, including TBI [11].

Despite the development of a comprehensive TBI Core Set [12], it remains unclear how behavior, illustrated in Figure 1, fits...
within the broader context of disability among individuals with TBI. The ICF linking rules capture manifest concepts; that is, what is specifically stated in an assessment question, observed by a rater, or measured by a tool. Behavior, in contrast, is a latent concept, or one that cannot be observed or measured directly. Content validity captures how well an assessment actually measures the latent construct it intends to measure. In other words, how well do the manifest concepts measured in the assessment match the latent construct the assessment was designed to capture. Using the linking rules for the ICF to code the manifest concepts in an assessment could therefore be used as a novel approach to demonstrating content validity. To that end, the purpose of the present study was to use the ICF to classify and describe the concepts of the initial version of the Behavioral Assessment Screening Tool (BAST) [2], a measure of behavioral disruptions after TBI.

The BAST was developed based on the conceptual model of behavior in Figure 1 [2] to specifically measure the multidimensional latent construct of behavior. Individuals with TBI, their family members, and clinicians with neurorehabilitation expertise contributed to the development of the BAST, to ensure meaningful content to multiple stakeholders [2]. It has demonstrated good psychometric properties in a cohort of adults with chronic TBI, including a high content validity index [2], multidimensional factor structure, and good internal consistency reliabilities [13]. The BAST includes items rated on a 1–5 ordinal scale, with subscales (e.g., factors) for Negative Affect, Substance Abuse, Executive Function, Fatigue, Impulsivity, and Maladaptive Coping, plus an Environmental Context Checklist of recent major life events (both positive and negative) that could directly affect emotional and behavioral functioning [13].

By linking the BAST concepts to the ICF using standardized rules, we can: (1) further explore the validity of the conceptual model of behavior represented by the BAST; (2) provide a novel indicator of the content validity of the BAST; (3) identify and clarify BAST items deemed confusing or unclear based on linking results; and (4) determine the comprehensiveness of the concepts included in the BAST as they relate to the ICF TBI Core Set.

**Methods**

### Linking concepts to the ICF

Three coders with an in-depth knowledge of the ICF independently applied the WHO-endorsed standardized ICF linking technique [14] to all meaningful concepts in each item of the BAST. "Item" refers to a single assessment question. A meaningful concept was defined as a single health aspect or an environmental factor with the potential to impact health status [15]. The first coder (CLO) linked the BAST concepts, strictly applying the 2016 refined linking rules (see Table 1), with no in-depth knowledge of what each BAST concept was designed to test. The second coder (DSK) linked 25% of the concepts using the same method as the first coder (CLO) in order to establish reliability. The third coder, the developer of the BAST assessment (SBJ), linked each BAST concept from the perspective of its intended purpose; the behavioral aspect the concept was designed to measure. From here, we will refer to the third coder’s (SBJ) linking as “latent coding” (coding of the underlying purpose of the concept known to the developer of the assessment) and the first and second coders’ linking as “manifest coding” (coding of the concepts as determined by the refined ICF linking technique [14]). We compared the linking results of the first manifest coder (CLO) to those of the latent coder (SBJ) as an indicator of content validity that goes beyond traditional psychometric testing. See coding results in Supplemental Document. Using the ICF linking technique in this way also provided insight into the validity of the conceptual model of behavior represented by the BAST and the comprehensiveness of the BAST by identifying how many categories in the TBI Core Set were covered by the BAST.

BAST concepts were linked to the ICF at the most specific level possible. Concepts that were too broad to link at the chapter level were linked at level one of the ICF taxonomy. The ICF is composed of five components: body structures (s), body functions (b), activities and participation (d), environmental factors (e), and personal factors (pf). All of these components, with the exception of personal factors, are broken down into chapters, which are further divided into categories. Some categories contain sub-
categories, and some sub-categories are further dissected into third and fourth level sub-categories. Categories become more detailed with each descending level. For this study, personal factor concepts were considered linkable to the ICF; however it should be noted that the personal factor component does not contain categories and has not been developed with the same scientific rigor as the other components [16].

Per the standardized linking instructions of Cieza et al. [14], concepts considered too vague or general for linking were labeled as "not defined (nd)". Concepts dealing with aspects of health or functioning that are not covered in the ICF were labeled as "not covered (nc)". All health conditions or diagnoses were labeled as "not covered-health conditions (nc-hc)" as they are considered to be linked to the ICF's partner document, the International Classification of Disease (ICD). Concepts clearly defined at a sub-category level not listed in the ICF were labeled using the "other specified" code. Concepts clearly defined at a category level but not specific enough to be labeled using a code provided in the ICF were labeled using the "unspecified" code. The perspective of each item was also determined according to the refined linking rules. Perspectives describe the purpose for which data are collected. There are three common perspectives outlined in the revised ICF linking rules. The first is the descriptive perspective. This describes one's functional abilities (i.e., How difficult is it for you to tie your shoe laces?). The second is the appraisal perspective. Appraisal perspective refers to the extent to which a person's expectations have been satisfied (i.e., How satisfied are you with your pain management?). The last perspective is needs/dependency. This perspective describes level of need an individual requires to function in daily life (i.e., How much assist do you require during meal time; help with cutting, opening jars, feeding, grasping cups, etc.). The type of response options was also determined for each item (i.e., intensity, frequency, duration, confirmation/agreement, qualitative attributes). Finally, the nature of each item was determined (i.e., whether the item addressed level of disability or level of function).

Meaningful concepts within each item were determined by the coders prior to the independent linking process. Concept meaning was determined based on the refined ICF linking rules recommendations, using the context and purpose of the BAST assessment to define the nature of the concept. The following is an example of how the coders defined and linked BAST concepts. The example item states, "I was able to walk away from a fight". According to the pre-refined rules "walk away" would be coded as the actual activity of "walking" which would distort the meaning of "walk away from a fight", as the item is clearly not designed to assess one's ability to walk. In this context "walk away" means to "avoid" the fight. The concept "walk away from a fight" was linked to the component Activities and Participation (d), chapter 7: Interpersonal interactions and relationships, second level category (20): Complex interpersonal interactions, third level

| Rule | Rule description |
|------|------------------|
| 1    | Acquiring knowledge of ICF chapters, domains, and categories |
| 2    | Identify the main concept based on the context and purpose of the assessment |
| 3    | Identify additional concepts in the item as above |
| 4    | Identify the perspective of each item |
| 5    | Document categorization of the response options (frequency, duration, intensity, confirmation, qualitative attributes) |
| 6    | Link concepts to most precise ICF level |
| 7    | Use "other specified" or "unspecified" ICF categories as appropriate |
| 8    | If a meaningful concept is too vague to link to ICF, assign concept "not definable" |
| 9    | If a concept is not contained in the ICF but is clearly a personal factor, assign "personal factor" |
| 10   | If a meaningful concept is not contained in the ICF, assign "not covered". Assign health conditions "health condition-not covered"

### Table 1. Refined linking rules as described by Cieza et al. [14] (paraphrased by authors).

| Rule | Rule description |
|------|------------------|
| 1    | Acquiring knowledge of ICF chapters, domains, and categories |
| 2    | Identify the main concept based on the context and purpose of the assessment |
| 3    | Identify additional concepts in the item as above |
| 4    | Identify the perspective of each item |
| 5    | Document categorization of the response options (frequency, duration, intensity, confirmation, qualitative attributes) |
| 6    | Link concepts to most precise ICF level |
| 7    | Use "other specified" or "unspecified" ICF categories as appropriate |
| 8    | If a meaningful concept is too vague to link to ICF, assign concept "not definable" |
| 9    | If a concept is not contained in the ICF but is clearly a personal factor, assign "personal factor" |
| 10   | If a meaningful concept is not contained in the ICF, assign "not covered". Assign health conditions "health condition-not covered"

### Table 2. Linking of BAST concepts to the ICF.

| BAST content | CLO | SBJ |
|--------------|-----|-----|
| Total number of questions | 92 |     |
| Total number of concepts | 134 |     |
| Content density (concepts per question) | 1.46 |     |

| Concepts linked to the ICF | CLO | SBJ |
|---------------------------|-----|-----|
| Body structures | 45 (34%) | 38 (28%) |
| Body functions | 30 (22%) | 43 (32%) |
| Activities and participation | 11 (8%) | 12 (9%) |
| Environmental factors | 16 | 15 |
| Personal factors | 102 | 108 |

| Concepts unable to be linked | CLO | SBJ |
|-----------------------------|-----|-----|
| Concepts considered health conditions (hc) | 0 | 0 |
| Concepts not definable (nd) | 16 (12%) | 13 (10%) |
| Concepts not covered by ICF or too vague (nc) | 16 (12%) | 13 (10%) |
| Total: unlinked concepts | 32 | 26 |

Numbers represent the number of concepts. Parentheses contain percentage of linked and unlinked concepts for each ICF component and unlinked classification.

### Reliability

To establish the inter-rater reliability of the linking process based on the most current version of the standardized ICF linking rules, the second coder (DSK) linked a random 25% of the BAST items. The level of agreement between coder one (CLO) and coder two (DSK) was established using percentage agreement and the kappa statistic. A kappa coefficient greater than 0.61 is considered good agreement [17]. Codes that were not agreed upon between the two raters were discussed and a final code assignment was made.

### Results

#### Linking to the ICF

A total of 134 concepts were identified among the 92 items included in the BAST. The manifest coder (CLO) found that 63% of concepts were linkable to the ICF. The latent coder (SBJ) found 69% of concepts to be linkable. Table 2 presents the BAST's codability, concept density, and component-level ICF coding for each rater. Concepts from the BAST were linked to 13 out of 30 ICF chapters by the manifest coder (CLO) and 15 out of 30 by the latent coder (SBJ). A kappa coefficient of 0.77 indicated good inter-rater reliability of the coding process between the two manifest coders at the ICF chapter level. Discussion was required five times (14%) in order to resolve linking difference of concepts considered linkable to the ICF. The perspective of the BAST is 64% descriptive, meaning the majority of BAST items describe a
person’s ability to perform a certain task or activity. An example in the BAST is the item: “when I had a problem to solve, I could think of multiple solutions”. This item probes a person’s ability to think of multiple solutions, it describes performance. Two percent of the items were of the needs/dependency perspective, meaning the items determined level of need or dependency. The BAST item “I needed alcohol to get through my day” addresses need or dependence on an environmental factor. The remaining 34% did not meet criteria for labeling of perspective, meaning it does not address ability to perform, satisfaction level, or level of need/dependency. For example, one item asks if the individual has experienced a change in residency, with a yes or no response option. This item does not aim to address a concept such as depression or self-efficacy, it is simply designed collect demographic data. Therefore, the item is not assigned a perspective. The majority of the BAST response options are frequency (66%). Thirty percent of items contain confirmation or agreement response options. One item contains an intensity response option, and four items require an open-ended qualitative response. The concept density (i.e., average number of concepts per item) was low (1.46), confirming the simplicity of individual item structure and the intention of each item to measure a single concept (e.g., no double-barreled questions).

**Body functions component**

Body functions are the physiological functions of body systems (including psychological functions)” [6]. The manifest coder (CLO) linked 45 (34%) of the 134 to this component. The latent coder (SBJ) linked 38 (28%) of concepts (see Figure 2). Of all concepts linkable to the ICF, the manifest coder linked the most to the body functions component. Both coders linked the majority of body functions concepts to Chapter 1: Mental functions. This chapter represents the most often linked chapter to the BAST by both coders (linked to 44 concepts by manifest coder, linked to 36 concepts by latent coder). Within this chapter, both coders linked the majority of concepts to the second level category: Emotional functions (b152). Emotional functions are “specific mental functions related to the feeling and affective components of the processes of the mind”. The second most often linked second level category by both coders was Thought functions (b160) or the pace, form, content and control of thoughts [6]. Both coders linked one BAST concept to Chapter 4: Functions of the cardiovascular, haematological, immunological and respiratory systems, to the category specifically addressing fatigability under the second level category: Exercise tolerance functions (b455). The latent coder (SBJ) linked one concept to Chapter 6: Genitourinary and reproductive functions, specifically, functions related to pregnancy under the category: Procreation functions (b660). This concept was coded as a “personal factor” by the manifest coder (CLO). The remaining 5 Body functions chapters were not linked to any concepts in the BAST assessment. Therefore, sensory functions and pain (b2), voice and speech functions (b3), functions of digestive, metabolic and endocrine systems (b5), neuromusculoskeletal and movement-related functions (b7), and functions of the skin (b8) are not address by the BAST assessment.

**Body structure component**

Body structures are defined by the ICF as “anatomical parts of the body such as organs, limbs, and their components” [6]. The body structures component of the ICF addresses all structures involved in the nervous system, structures of the eyes and ears, structures of voice and speech, structures of cardiovascular, immunological and respiratory systems, structures related to digestion, metabolic and endocrine systems, structure related to genitourinary and reproductive systems, structures related to movement, and structures related to skin. No concepts were linked to the body structures component by any of the coders. The BAST does not address behavior as it relates to specific body structures.

**Activities and participation component**

The ICF defines activity as “the execution of a task or action by an individual” and participation is defined as “involvement in a life situation” [6]. The manifest coder (CLO) linked 29 (22%) concepts to this component. The latent coder (SBJ) linked 43 (32%) concepts (see Figure 3). Of all concepts linkable to the ICF, the latent coder linked the most to the activities and participation component. The majority of activities and participation concepts were linked by both coders to chapter 2: General tasks and demands and chapter 7: Interpersonal interactions and relationships. Of concepts linked to chapter 2: General tasks and demands, both coders linked all concepts to the level two categories: undertaking a single task (d210), carrying out daily routine (d230), and handling stress and other psychological demands.
(d240), and general tasks and demands-unspecified (d299). Of concepts linked to chapter 7: interpersonal interactions and relationships, both coders linked concepts to the level two categories: basic interpersonal interactions (d710), complex interpersonal interactions (d720), and intimate relationships (d770). The latent coder (SBJ) also linked one concept to family relationships (d760) and one concept to interpersonal interactions and relationships-unspecified (d799). No BAST concepts were linked to activities and participation area of domestic life.

Environmental factors component

The ICF defines environmental factors as “factors that make up the physical, social, and attitudinal environment in which people live and conduct their lives” [6]. The manifest coder (CLO) linked 11 (8%) concepts to this component. The latent coder (SBJ) linked 12 (9%) concepts (see Figure 4). Both coders linked the majority of concepts linked to the environmental factors component to chapter 2: natural environment and human-made changes to the environment and chapter 3: support and relationships. Both coders linked concepts linked to chapter 2 to the second level subcategory of natural events (e230) and human-caused events (d235). Both coders linked concepts linked to chapter 3 to the level sub-categories of: immediate family (e310), friends (e320), health professionals (e355), and support and relationships-unspecified (e399). The manifest coder (SBJ) linked one concept to chapter 1: Products and technology, specifically, products or substances for personal consumption (e110). Both coders linked one concept to chapter 5: Services, systems and policies. The manifest coder (CLO) linked this concept to second level subcategory: health services, systems and policies (e580). The latent coder (SBJ) linked one concept to the second level subcategory: associations and organizational services, systems and policies (e555). No coders linked BAST concepts to chapter 4: Attitudes.

Comparing BAST concepts to the TBI Brief Core Set

The ICF is a comprehensive framework of human functioning as it relates to health and, in its entirety, it is likely not relevant to the description of functioning after TBI. Therefore, the WHO’s ICF Research Branch developed an ICF Core Set to narrow the focus of the ICF to aspects most relevant to the diagnosis of TBI [12]. Of 363 ICF second level categories, 139 were selected for the TBI Comprehensive Core Set. Twenty-three categories from the Comprehensive Core Set were selected for the TBI Brief Core Set. The Brief Core Set is a list of the ICF categories deemed most
essential in understanding the lived experience of individuals with TBI [18]. The BAST assessment addresses 74% (17/23) of the TBI Brief Core Set categories at least once, which suggests that the BAST addresses the majority of areas deemed most essential in understanding the experience of living with a TBI. The 17 Core Set categories in the BAST are represented either as a concept linked to an ICF category or as a personal factor.

Discussion

The majority of the TBI Core Set categories were represented in the BAST and, reflective of the TBI Brief Core Set, most BAST concepts were related to the body functions and activities and participation components. Most concepts were linked to the ICF categories of emotional functions, thought functions, general tasks and demands, interpersonal interactions and relationships, natural environment and human-made changes to the environment, and support and relationships.

The six categories included in the Brief Core Set that are not addressed in the BAST include two body functions categories, one body structures category, one activities and participation category, and two environmental factors categories. The body functions categories not addressed in the BAST are consciousness functions (b1110) and control of voluntary movement functions (b760); control and coordination of voluntary movement. Consciousness functions are general mental functions that support the state of awareness and alertness; it is the state, continuity and quality of consciousness. This category does not include orientation, energy and drive or sleep functions. That the BAST does not include these body functions categories is consistent with its purpose, as the BAST was designed to be completed independently by individuals with TBI and is not intended for individuals in minimally conscious states, vegetative states, or drug-induced altered consciousness. The Brief Core Set lists only one body structures category: Structures of the brain (s1110). The BAST assessment contains no concepts linked to body structures mainly because the assessment was developed to screen for behavioral dysfunction in chronic TBI. It is, therefore, assumed that structural diagnostic findings that may be relevant to behavior are available through medical records or would be conducted in comprehensive clinical evaluation, as needed. Walking (d450) is the activities and participation category in the Brief Core Set that was not linked to a category in the BAST. Walking (d450) includes walking short or long distances, walking on different surfaces and walking around objects. The BAST does not address mobility of any means (walking or use of assistive device). Though mobility may be associated with community participation and mental health, it is not directly reflective of disrupted behavior. Individuals completing the BAST do have the opportunity to note, in response to an open-ended question, anything else that may be significantly affecting them, such as limitations in walking or other voluntary, coordinated movements. Finally, the Brief Core Set includes the environmental factors, productions and technology for personal using in daily living (e1115) and social security services, systems, and policies (e570). The BAST does not address general or assistive products and technology for personal use in daily living. Use of assistive or mobile technology will be added to the Environmental Context section of the BAST, particularly in light of the growing use of mobile health to support emotional and behavioral functioning after TBI [19]. The BAST does not specifically address utilization of services, systems, and policies designed to support those who may require public assistance, but it does address broader financial dilemma, by asking if an individual has recently experienced an increase in financial stresses. Change in public assistance services could be added to the Environmental Context checklist component of the BAST to address this component of the Brief Core Set.

Using the ICF to examine content validity

In this study, we compared the coding results of the assessment developer/latent coder (SBJ) to those of an experienced coder who did not have insight into the specific purpose of each assessment item (CLO). This method demonstrates the utility of the ICF linking technique as a supplemental way to examine the content validity of an assessment tool beyond traditional methods. When comparing the manifest coding (CLO) results with the latent coding results (SBJ) of the assessment’s developer, disagreement occurred only 15% of the time (20/134). This low rate of discrepancy between the assessment developer and the second coder is likely due, heavily in part, to the refinement of Linking Rule 2. With this refinement, coders can now interpret the context of an assessment item in order to define the main concept. Prior to the refinement, the linking rules required that coders linked concepts at face-value without considering the item’s purpose. The true nature or intention of the item was sometimes lost to idiomatic phrases or peripheral concepts used to increase clarity of meaning (as in the example provided earlier of “walking away from a fight”).

The refinement of Linking Rule 2 expands the utility of the ICF linking technique as a tool that can more thoroughly explore the content validity of assessments. For example, a BAST item states, “I needed to rest or nap to get through my day”. “Rest” was considered as “not covered” by the ICF by the manifest coder (CLO) and as quality of sleep (b1343) by the latent coder (SBJ). “Nap” was coded as quality of sleep (b1343) by the manifest coder (CLO), and as looking after one’s health-other specified by the latent coder (SBJ). The BAST developer used “rest” and “nap” interchangeably in this item. However, through the comparison of linking results and the discussion of the coders’ discrepancies, it was determined that “rest” and “nap” in this context are two distinct concepts with different meanings. The intended purpose of the item was to assess fatigue and the impact of fatigue on daily functioning. Lacking the energy to a point that rest is consistently required to get through the day, in this context, is considered “dysfunctional”, whereas napping may be an effective “functional” strategy for managing lack of energy. Through discussion, the coders determined that this is a double-barreled item that would better address the intended purpose if it were worded simply as, “I needed rest to get through my day”. This change will be made for future versions of the BAST. Overall, frequency of double-barreled was low. A concept density score of 1.46 suggests that the BAST has an average of less than two concepts per item which confirms the simplicity of each item, an assessment characteristic that is crucial when gathering data in populations with cognitive deficits such as TBI.

Despite the coders’ overall low discrepancy rate, a significant contributor to coding disagreement among the linked concepts was the coding of the concept of “stress” which appears multiple times throughout the BAST. The manifest coder linked the majority of concepts to body functions (b) whereas the latent coder linked the majority of concepts to the activities and participation (d) component, this is largely explained by the coders’ differing interpretations of the concept of “stress”. An example item is, “when I was stressed, I was unable to make decisions”. The manifest coder (CLO) linked the concept “stressed” in this context to the body functions component: emotional functions-unspecified (b1529),...
which is specific mental functions related to the feeling and affective components of the processes of the mind. The latent coder (SBJ) linked the same concept to the activities and participation component: handling stress (d2401), which is carrying out actions to cope with pressure associated with task performance. In this case, the BAST developer/latent coder (SBJ) designed these items with the intention of assessing ability to cope in stressful situations. The developer (SBJ), therefore, linked the concept of “stress” in this context to the ICF code for the act of managing stress, whereas the manifest coder (CLO), who had no insight into the intended purpose of the items, linked this concept to the ICF code of mental functions related to the feeling of an emotion. The authors propose that, while the concept was interpreted differently by each coder, the linking is accurate in both cases and represents the difference in perspectives of the coders (knowing the intention of the item vs. not). However, in this case, the actual intention of the item is masked by the manifest coder’s (CLO) selection. As Cieza et al. [14] discuss, the refined ICF linking rules provide researchers and clinicians with a transparent and reliable mechanism to classify and describe health data using a universal language, yet this method is sometimes limited in its ability to capture all the nuances of a complex data collection tool. Therefore, coding technique transparency, in-depth discussion of coding discrepancies, and multiple coders are essential to ensure reliability of the results.

A case for inclusion of “behavior management” in the ICF

The ICF Child and Youth (ICF-CY) Version contains the second level category “managing one’s own behavior”. This includes “carrying out simple or complex and coordinated actions in a consistent manner in response to new situations, persons or experiences...” [6]. The concept is further defined as accepting novelty, responding to demands, approaching persons or situations, acting predictably, and adapting activity level. The adult ICF does not include the concept of “managing one’s own behavior”. The authors argue that the ability to manage one’s behavior is a critical component of cognitive, emotional, and physical health of both adults and children and should be included in future editions of the ICF. One example from the BAST where the “behavior management” category would be appropriate is, “other people complained to me about how I acted”. “How I acted”, or in other words, “how I managed my behavior” is a health-related concept that is relevant not only to individuals with TBI, but to the overall health and functioning of all individuals.

Limitations

In this study, one coder linked all concepts and a second linked 25% of randomly selected concepts to determine reliability. This potentially biased the results towards the assessment of the main coder, ideally at least two trained coders would have linked all of the concepts included in the BAST. A second issue, which may be more of a limitation of the ICF than of the study, is the incompleteness of the ICF framework. The ICF has been heavily vetted and widely applied, yet it is a living document that is subject to reviews, updates and revisions. Although infrequent, the BAST contained a few clear, well-defined concepts that could not be directly defined by the ICF. One example of this is in item 21 of the BAST. The item states, “I lied or exaggerated”. The concepts of “lying” and “exaggerating” are not included in the ICF. Although the concepts are clear, they could not be linked. Therefore, the meaning of this concept was lost to the linking process, potentially biasing the resulting analysis.

Conclusions

Linking the BAST concepts (i.e., individual items) to the ICF using standardized rules demonstrated the BAST’s content validity and comprehensiveness for individuals with chronic TBI. Furthermore, this approach provides a model for how ICF coding could be used to assess content validity and inform refinement of other measurement tools used in rehabilitation.

Disclosure statement

The authors report no declarations of interest.

ORCID

Shannon B. Juengst [http://orcid.org/0000-0003-4709-545X

References

[1] Juengst SB, Switzer G, Oh BM, et al. Conceptual model and cluster analysis of behavioral symptoms in two cohorts of adults with traumatic brain injuries. J Clin Exp Neuropsychol. 2017;39:513–524.
[2] Juengst SB, Terhorst L, Dicianno BE, et al. Development and content validity of the behavioral assessment screening tool (BAST)). Disabil Rehabil. 2018. DOI:10.1080/09638288.2017.1423403
[3] Rao V, Lyketsos C. Neuropsychiatric sequelae of traumatic brain injury. Psychosomatics. 2000;41:95–103.
[4] Boyle E, Cancelliere C, Hartvigsen J, et al. Systematic review of prognosis after mild traumatic brain injury in the military: results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. Arch Phys Med Rehabil. 2014;95:S230–S237.
[5] James LM, Strom TQ, Leskela J. Risk-taking behaviors and impulsivity among veterans with and without PTSD and mild TBI. Mil Med. 2014;179:357–363.
[6] World Health Organization. International classification of functioning, disability and health: ICF. Geneva: WHO; 2001.
[7] Cieza A, Stucki G. The International Classification of Functioning Disability and Health: its development process and content validity. Eur J Phys Rehabil Med. 2008;44:303–313.
[8] Osborne CL, Kauvar DS. A content analysis of peripheral arterial disease patient-reported outcome measures using the International Classification of Functioning, Disability and Health. Disabil Rehabil. 2017. DOI:10.1080/09638288.2017.1390699
[9] Osborne CL, Petersson C, Graham JE, et al. The Burn Model Systems outcome measures: a content analysis using the International Classification of Functioning, Disability, and Health. Disabil Rehabil. 2017;39:2584–2593.
[10] Cieza A, Ewert T, Ustun TB, et al. Development of ICF Core Sets for patients with chronic conditions. J Rehabil Med. 2004;36:9–11.
[11] 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. 2014;51:105–117.
[12] Laxe S, Zasler N, Selb M, et al. Development of the International Classification of Functioning, Disability and...
Health core sets for traumatic brain injury: an International consensus process. Brain Inj. 2013;27:379–387.

[13] Juengst SB, Terhorst L, Dicianno BE, et al. Factor structure of the Behavioral Assessment Screening Tool (BAST) in traumatic brain injury. Disabil Rehabil. 2018;1. (in press).

[14] Cieza A, Fayad N, Bickenbach J, et al. Refinements of the ICF Linking Rules to strengthen their potential for establishing comparability of health information. Disabil Rehabil. 2016. DOI:10.3109/09638288.2016.1145258

[15] Offenbach M, Cieza A, Brockow T, et al. Are the contents of treatment outcomes in fibromyalgia trials represented in the International Classification Of Functioning, Disability, and Health? Clin J Pain. 2007;23:691–701.

[16] Simeonsson RJ, Lollar D, Bjorck-Akesson E, et al. ICF and ICF-CY lessons learned: Pandora’s box of personal factors. Disabil Rehabil. 2014;36:2187–2194.

[17] Brennan P, Silman A. Statistical methods for assessing observer variability in clinical measures. BMJ. 1992;304:1491–1494.

[18] 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;51:105–117.

[19] Juengst ST, Sander AM, Nalder E, et al. Mobile health interventions after traumatic brain injuries. Curr Top Phys Med Rehabil Rep. 2018. (in press).