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Social-Emotional Outcomes in Children with Hydrocephalus

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Abstract

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Hydrocephalus can impact all areas of health, including physical, cognitive, and social-emotional functioning. The social-emotional health of children who have had surgery for their hydrocephalus is not well characterized. This study examined social-emotional and behavioral functioning using the Behavioral Assessment System for Children, Third Edition (BASC-3) and the Hydrocephalus Outcome Questionnaire (HOQ) in children aged 5-17 years old. BASC-3 parent report scores were compared to the BASC-3 normative sample using one-sample t-tests to evaluate overall social-emotional functioning. BASC-3 scores were correlated with the social-emotional domain of the HOQ using Pearson's r to determine if the HOQ accurately captures the social-emotional functioning of children with hydrocephalus in a neurosurgery setting. BASC-3 and HOQ scores of children with different etiologies of hydrocephalus were compared using one-way ANOVAs. Children with hydrocephalus of all etiologies had more difficulties with social-emotional functioning compared to normative populations, but there were no differences in functioning between etiologies. The social-emotional domain of the HOQ correlated more strongly with the BASC-3 than did the physical and cognitive domains. These results provide evidence that children who have had surgery for their hydrocephalus may be at increased risk of social-emotional and behavioral difficulties, but etiology may not be particularly helpful in predicting what kinds or degree of difficulty. This study also supports the content and divergent validity of the social-emotional domain of the HOQ.

Keywords: hydrocephalus, BASC-3, Hydrocephalus Outcome Questionnaire

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Social-Emotional Outcomes in Children with Hydrocephalus

Hydrocephalus is the most common disease treated by pediatric neurosurgeons (Simon et al., 2008) and generates a substantial emotional and financial burden for individuals, families, and health care centers. It is a disease characterized by obstruction or hypersecretion of cerebrospinal fluid resulting in ventriculomegaly, which causes disrupted white matter tract development and myelination, vascular damage, and chronic inflammation (Kahle, Kulkarni, Limbrick, & Warf, 2016; Tully & Dobyns, 2014). The sequela from these processes are varied and complex depending on the etiology and severity of hydrocephalus (Kahle et al., 2016). Children with hydrocephalus often have additional medical conditions that impact development and prognosis. Due to the numerous issues associated with hydrocephalus, it is challenging to obtain a comprehensive picture of the child's health status and generate a holistic treatment plan.

Health Status in Hydrocephalus

Health status is often evaluated in three domains: physical, cognitive, and social/emotional/behavioral. Children seen for hydrocephalus are routinely evaluated for functioning in the physical domain, such as sleep, eating habits, and mobility. Complications directly related to the hydrocephalus treatment, such as infection, shunt failure, or increasing ventricle size, are also closely monitored (Erps, Roth, Constantini, Lerner-Geva, & Grisaru-Soen, 2018; Kahle et al., 2016; Kestle et al., 2016; Riva-Cambrin et al., 2016). Increasingly, cognitive function is a priority when evaluating neurosurgical outcomes. In particular, children with hydrocephalus generally have lower IQ scores on standardized testing and more attention difficulties observed on both parent-report and standardized tests of attention and these deficits often persist into adulthood (Arrington et al., 2016; Ball et al., 2013; Jenkinson et al., 2011; Kulesz et al., 2015; Kulkarni, Donnelly, & Shams, 2011; Swartwout et al., 2008). Despite some evidence that children with hydrocephalus have more problems with behavior and social-emotional functioning than their peers (Helder, Austria, Lacy, & Frim, 2011; Lindquist, Carlsson, Persson, & Uvebrant, 2006; Sumpter, Dorris, Brannan, & Carachi, 2012), this domain is often overlooked as a treatment consideration and a focus of research in the neurosurgery setting. To optimize treatment outcomes, all domains of health should be 1) well-characterized in this population in order to provide outcome expectations and recommendations to families and treatment teams and 2) routinely monitored in the neurosurgery setting as this is the primary medical point of contact for many children with hydrocephalus.

Health-related quality of life (HRQL) measures are useful for capturing the overall functioning of patients and to track changes in health status over time. While general HRQL measures such as the Health Utilities Index (HUI) (Furlong, Feeny, Torrance, & Barr, 2001) capture a broad picture of health status, condition-specific measures allow clinicians to obtain information that may be unique or of higher importance to a given population. The Hydrocephalus Outcome Questionnaire (HOQ) is a 51-item hydrocephalus specific HRQL questionnaire that measures cognitive, social-emotional, and physical health outcomes in hydrocephalus (Kulkarni, Rabin, & Drake, 2004). The HOQ correlates well with established neuropsychological assessments, but its social-emotional domain is less studied (Kulkarni et al., 2011). To confirm the utility of the HOQ as a clinical and research tool that adequately measures all three domains of health status, additional research on its social-emotional domain is needed.

Social-Emotional and Behavioral Health in Hydrocephalus

Children with hydrocephalus appear to experience both internalizing and externalizing emotional symptoms at higher rates than the general population (Donders, Rourke, & Canady, 1992; Fletcher et al., 1995) and may have higher rates of autism (Lindquist et al., 2006) but there are few recent studies of this aspect of health. In a small study examining social-emotional functioning with the BASC-3, Helder and colleagues (2011) found that children with hydrocephalus have higher levels of depression, somatization, attention problems, and atypicality, but this study was limited to only children with hydrocephalus due to post-intraventricular hemorrhage. Additionally, the analysis was not corrected for multiple comparisons, so the study may have over-represented emotional and behavioral difficulties in these children.

Current research examining non-surgical hydrocephalus outcomes other than IQ and attention typically addresses executive function (Burmeister et al., 2005; Helder et al., 2011; Lacy, Baldassarre, Nader, & Frim, 2012; Mahone, Andrew Zabel, Levey, Verda, & Kinsman, 2002; Zabel et al., 2011). Executive function generally refers to one's ability to reason, problem solve, and plan (Blair, 2017). Executive functioning is a component of social-emotional and behavioral functioning as it can impact a child's ability to regulate and express their emotions. The ability to plan and reason strongly influences behavior and social functioning, but measures of executive functioning do not capture internalizing symptoms such as depression and anxiety as well as they capture externalizing symptoms such as hyperactivity and impulsivity. Measures of executive function also do not give specific information about what emotional difficulties may be driving a child's problems with planning and reasoning. Examining individual internalizing and externalizing symptoms such as anxiety, depression, hyperactivity, and aggression as well as executive functioning may help to target intervention for children with hydrocephalus who have behavior problems.

Hydrocephalus Etiologies

Clinical course and prognosis for children with hydrocephalus can vary widely according to the cause of the hydrocephalus. Due to the variability in clinical course, research conducted with children with hydrocephalus is often limited to one or two etiologies (Helder et al., 2011; Jenkinson et al., 2011; Kulesz et al., 2015; Swartwout et al., 2008; Zabel et al., 2011). While appropriate when the goal of the study is to examine the functioning of a subset of children with hydrocephalus or to reach statistical significance, the clinical significance of these studies is limited. Even within a given etiology, such a myelomeningocele, comorbid conditions can vary between patients according to the location of the myelomeningocele. Children evaluated in a neurosurgery setting have a variety of etiologies, and their families need to have as much access to information and resources as possible.

The primary purpose of this study was to first examine social-emotional functioning in children who have undergone surgical treatment for hydrocephalus of different etiologies using an established measure of behavioral and social-emotional functioning, the Behavior Assessment System for Children, Third Edition (BASC-3). An excellent and commonly used tool in psychological settings, the length and cost of the BASC-3 and similar measures make them unlikely candidates for regular clinical or research use in the neurosurgery setting. Rather than excluding etiologies, this study included 4 of the most frequent etiologies of hydrocephalus seen at Primary Children's Hospital (e.g., myelomeningocele, post-intraventricular hemorrhage due to prematurity, aqueductal stenosis, and communicating congenital hydrocephalus) and combined remaining etiologies into an "other" category. This allowed us to gain a more comprehensive picture of the social-emotional functioning of children with hydrocephalus than if we were to restrict the study to one etiology. Statistical limitations due to small group sizes were considered acceptable in light of the goal to describe social-emotional functioning across all children with hydrocephalus. The secondary purpose of this study was to determine if lower scores (e.g., worse health) on the social-emotional domain, but not the physical and cognitive domains, of the Hydrocephalus Outcomes Questionnaire (HOQ) are associated with higher scores (e.g., more difficulties) on the BASC-3. This would provide evidence for the divergent and content validity of this domain, and lend support to the use of the HOQ in a neurosurgery setting to screen for social-emotional difficulties in patients. A single, free, short questionnaire that assesses physical, cognitive, and social-emotional health would be a crucial tool to screen for areas of concern that warrant additional follow up in children with hydrocephalus.

We hypothesized that children who have hydrocephalus due to various etiologies will differ from each other, and from the normative sample, on the BASC-3 Internalizing and Externalizing composite scales and Executive Function content scale. Additionally, we hypothesized differences between etiologies on the HOQ total score and the HOQ social-emotional score. Finally, we expected that the social-emotional domain of the HOQ will have a stronger correlation with BASC-3 clinical, adaptive, and content scales and that the physical and cognitive domains will correlate less with BASC-3 scores.

Method

Participants

Participants were 30 caregivers of children who received surgery for hydrocephalus at Primary Children's Hospital who are part of an ongoing study with a total anticipated enrollment of 100-200. Patient ages ranged from 8 to 16 years with a mean age of 10.4; 27% were female and 73% were male. Age at the time of first permanent cerebrospinal fluid (CSF) diversion surgery ranged from 1 day to 7.7 years, with a mean age of 1.06 years (Table 1). Neurosurgeons at Primary Children's Hospital (PCH) contribute data from all children who received surgery for their hydrocephalus to a national database. Caregivers of all patients age 5-17 with an etiology entered in the database were contacted for participation. Although the HOQ has been translated and used in Spanish (Iglesias et al., 2018), validity and reliability evidence for the Spanish version is limited, therefore, only the English version was used. Families who were unable to complete the English versions of the HOQ and the Behavior Assessment System for Children (BASC-3) were excluded. Due to family burden and variability in health status soon after surgery, participants who had their first neurosurgical intervention within the past 6 months were excluded. See Table 1 for a summary of patient characteristics.

Measurement

Behavioral Assessment System for Children, Third Edition (BASC-3). The BASC-3 Parent Rating Scales (PRS) was administered to characterize social-emotional functioning in this population. The BASC-3 is a 139 to 175 item (depending on age range) measure for assessing behavioral and emotional problems in children that has undergone extensive reliability and validity testing. It is normed for general and clinical populations of children in the United States. Items for the PRS are written at a 4th grade level, making the measure accessible to most parents, regardless of education level.

Clinical scales for the BASC-3 were developed by comparing responses between children with no identified clinical diagnosis and those with general clinical problems, ADHD, autism, or emotional or behavioral disturbance. The following clinical scales were generated, which reliably differentiate between typical children and those with clinical presentation of emotional or behavioral problems: aggression, anxiety, attention problems, atypicality, conduct problems, depression, hyperactivity, learning problems, somatization, and withdrawal. In addition, the adaptive scales (activities of daily living, adaptability, functional communication, leadership, social skills, study skills) were developed to assess for functioning in a number of positive domains. Content scales (anger control, bullying, developmental social disorders, emotional self-control, executive functioning, negative emotionality, resiliency), composite scales (externalizing problems, internalizing problems, adaptive skills, behavioral symptoms index), a clinical probability scale, and a functional impairment scale were developed as well. For all scales, scores are reported as T-scores with a mean of 50 and SD of 10. A T-score of 60-69 is considered "at risk" and a T-score of 70 or above is considered "clinically significant." Items are answered with a 4 level Likert scale (never, sometimes, often, always). The BASC-3 contains items like "my child is sad" and "my child is nervous." (3rd Ed. BASC-3, Reynolds & Kamphaus, 2015).

Internal consistency across ages and gender for the BASC-3 range from .78-.95 for the clinical scales, .88-.97 for the composite scales, and .73 to .96 for the content scales in the general norm samples. Test-retest reliability, measured by repeat administration to the same caregiver 7-70 days after the first administration ranges from $r = .87$ to $r = .93$. Inter-rater reliability between different caregiver responses on the PRS range from $r =.59$ to $r = .86$. Some variability is expected between different caregivers as each is likely to observe different components of the child's behavior, therefore, for this study, the primary caregiver was asked to complete the questionnaires whenever possible. The BASC-3 has moderate to high correlations with other measures of behavioral and emotional functioning, such as the Achenbach System of Empirically Based Assessment Child Behavior Checklist (ASEBA CBCL), Conners 3, Autism Spectrum Rating Scale (ASRS), and Delis Rating of Executive Function.

Hydrocephalus Outcome Questionnaire. The Hydrocephalus Outcome Questionnaire (HOQ) is a 51-item instrument designed to measure the physical, cognitive, and social-emotional functioning of children age 5-17 years with hydrocephalus (Kulkarni, Rabin, et al., 2004). The questionnaire is parent report and items are answered with a 5 item Likert scale (not at all true, a little true, somewhat true, quite a bit true, very true). The social-emotional domain contains items like “My child is often irritable” or “My child worries about the future.” The HOQ has since been used in a number of studies examining health outcomes in children with hydrocephalus (Karmur & Kulkarni, 2018; Kulkarni et al., 2011; Kulkarni, Sgouros, Leitner, & Constantini, 2018; Platenkamp, Hanlo, Fischer, & Gooskens, 2007) The scale and scoring instructions of the HOQ are freely available (Kulkarni, Drake, et al., 2004).

Scoring of the HOQ provides scores from 0.0 (worse health status) to 1.0 (better health status) (Kulkarni, Drake, et al., 2004). Kulkarni (2006) indicates that a clinically meaningful difference in HOQ scores is 0.10 or greater. Internal consistency from the initial test development, measured with Cronbach α, was 0.94 for overall health, 0.93 for physical health, 0.82 for social-emotional health, and 0.91 for cognitive health. Test-retest reliability, with the questionnaire re- administered a mean of 18 days apart, was 0.93 for overall health, 0.98 for physical health, 0.84 for social-emotional health, and 0.92 for cognitive health. Responses from mother-father pairs who both filled out the HOQ were evaluated for interrater reliability, with a correlation of 0.88 for overall health, 0.96 for physical health, 0.76 for social-emotional health, and 0.76 for cognitive health.

Content validity was evaluated by an expert panel of pediatric neurosurgeons to ensure adequate breadth of coverage of health status items for children with hydrocephalus. Construct validity was evaluated by correlating HOQ scores with several established measures of health, the WeeFIM, a measure of physical and overall health, the SDQ, a measure of social-emotional health, the WRAT, a measure of cognitive health, and the HUI-2, a measure of overall health. Correlations were moderate to high (.59-.89) between HOQ domains and their corresponding external measure. Since its development, the HOQ has been compared to a comprehensive neuropsychological battery (Kulkarni et al., 2011) and found to have good convergent validity between the cognitive domain and neuropsychological tests, as well as divergent validity between the physical and social-emotional domains and neuropsychological tests. While the HOQ has been used in a variety of populations since its development, including adults (Jenkinson et al., 2011) and Spanish-speakers (Iglesias et al., 2018), additional research is needed to establish its validity and utility in populations outside of that in which it was developed. This study used the HOQ to 1) evaluate the overall quality of life in children with hydrocephalus using all three domains of the HOQ and 2) examine how well the social-emotional domain of the HOQ corresponds with a well-established and more comprehensive measure of social-emotional problems (the BASC-3).

Procedure

Eligible participants were identified from a nationwide database that neurosurgeons at Primary Children's Hospital (PCH) contribute to on all children who have had surgery for their hydrocephalus. The parents/guardians of eligible patients were sent a letter describing the study, then were called to see if they would like to participate. Participants were then emailed links to the surveys. HOQ data were collected using REDCap electronic data capture system hosted at the University of Utah. REDCap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies. (Harris et al., 2019, 2009) The first page of the REDCap survey was a consent document. Additional background information (history of seizures, family income, and parental education) was asked on the last page of the REDCap survey. BASC-3 data were collected via Pearson's secure, web-based assessment system. The unique subject identifiers that had already been generated for the database were used for all study participants to maintain participant confidentiality. Data extracted from the neurosurgery database include: etiology, date of birth, sex, number, date, and type of neurosurgical procedures, and number of shunt infections. Neurosurgical procedures included were primary shunt placements, shunt revisions, and endoscopic third-ventriculostomies (ETVs). Temporary CSF diversion procedures such as subgaleal shunts and external ventricular drains were not included as procedures since these strategies are not used for long-term hydrocephalus management (Eid et al., 2018).

Data Analysis

Prior to performing analyses, data were cleaned and prepared. All continuous variables were examined for outliers and assumptions of normality. Two internalizing composite scores appeared to be outliers (e.g., beyond the median value +/- 2 interquartile ranges). These two extreme scores appear to also produce some skewness in the data. Both BASC-3 reports were examined individually, and the response patterns appeared to be an accurate representation of the functioning of those children, so the data points were left unchanged and no transformations were conducted on the data.

One-sample t-tests were performed on the internalizing and externalizing BASC-3 composite scores and the executive function content scales to examine differences in maladaptive behavior between children with hydrocephalus and the BASC-3 normative population. A Bonferroni correction was applied to account for multiple comparisons. One-way ANOVA was conducted to examine differences between the 5 etiology groups in terms of BASC-3 internalizing and externalizing composite scores and the executive function content scales and HOQ overall and social-emotional scores. Pearson *r* correlation coefficients were calculated between BASC-3 clinical scales, adaptive scales, externalizing and internalizing composite scores, and the executive function and developmental social disorders content scales with the HOQ domain and overall scores to determine if the HOQ social-emotional domain correlates more highly with the BASC-3 than its other domains. Higher HOQ scores indicate better functioning, while higher BASC-3 scores indicate worse functioning, with the exception of the adaptive scales, where a higher score indicates better functioning.

Results

Results from the one-sample t-tests revealed significantly higher scores on the BASC-3 internalizing $t(29) = 3.15$, $p = .004$, externalizing $t(29) = 3.02$, $p = .005$, and executive functioning $t(29) = 6.56$, $p < .001$ scales for children with hydrocephalus compared to normative scores (Table 2). There were no statistically significant in BASC-3 internalizing, and externalizing composite scores and the executive function content scales and HOQ overall and social-emotional scores based on etiology (Table 3). The HOQ social-emotional domain had a correlation of .4 or greater with 16 of the 18 BASC-3 scales examined, while the HOQ cognitive domain only had similar correlations with 5 BASC-3 scales and the HOQ physical domain with just 3 BASC-3 scales. Nine of the 18 BASC-3 scales had a correlation of .5 or higher with the social-emotional domain, compared to just 3 scales that correlated this highly with the cognitive domain and just 1 scale for the physical domain (Table 4).

Discussion

The overarching aim of this study was to examine social-emotional and behavioral functioning in a mixed etiology sample of children with hydrocephalus. The secondary aim was to examine the convergent and divergent validity of the social-emotional, cognitive, and physical domains of the Hydrocephalus Outcome questionnaire. Based on the results of this study, children with hydrocephalus appear to experience both more internalizing symptoms (e.g., anxiety, depression, and somatization) and externalizing symptoms (e.g., hyperactivity, aggression, and conduct problems). The difference between children with hydrocephalus and the BASC-3 normative sample on executive functioning was the largest of the three scales examined, with an effect size of 1.2. This supports other research that children with hydrocephalus are more likely to be perceived by their caregivers as having problems with executive functioning (Burmeister et al., 2005; Helder et al., 2011; Lacy et al., 2012; Mahone et al., 2002; Zabel et al., 2011). The executive functioning content scale of the BASC-3 includes questions about planning, inhibiting responses, maintaining goal-directed activity, and anticipating events. These questions cover a broad range of the many components of executive functioning. With a larger sample size, it would be useful to conduct a factor analysis on the executive function scale items to identify patterns of types of executive functioning deficits in this population.

Providing parents with the knowledge that children with hydrocephalus are more likely to have these difficulties may help to alleviate some of the frustration and confusion that can be associated with the onset of behavioral symptoms. Several of the parents contacted for this study indicated that they have been struggling for years with their child's behavioral and emotional difficulties. A brief screening or review of emotional and behavioral symptoms at neurosurgery clinic visits could provide an opportunity to connect families with resources. If families are informed about what kinds of behaviors to look for, early intervention can be sought, resulting in better long-term outcomes. Similarly, treatment teams who are familiar with the typical social and emotional difficulties of children with hydrocephalus can make appropriate referrals.

BASC-3 and HOQ scores did not significantly differ between etiology groups. To detect a difference between 5 groups at $\alpha = .05$, with an effect size of 0.3 at 80% power, 140 participants are needed; effect sizes in our analysis ranged from .006 to .11 (Table 3) (Faul, Erdfelder, Lang, & Buchner, 2007). The standard deviations of average scores for each etiology were relatively high, reflecting the variability in functioning in children with hydrocephalus, even within the same etiology group. While this variability may result in non-statistically significant results, characterizing the general distributions of functioning in different etiology groups can help generate ideas about how best to evaluate and treat children with hydrocephalus. Data collection is ongoing, and it will be interesting to see patterns in scores between different etiologies once a larger sample size is acquired. The estimated final sample size for this study is 100.

It is notable that on average, children with hydrocephalus of all etiologies were in the “at-risk” range (T-score of 60-69) for executive functioning difficulties, and children with an etiology of myelomeningocele were “at-risk” for internalizing symptoms, while those with an etiology of communicating congenital hydrocephalus were “at-risk” for externalizing symptoms. Children with myelomeningocele etiology had overall HOQ scores that were on average at least .10 point lower than those with aqueductal stenosis or other etiology, and they had social-emotional scores that were on average at least .10 point or more lower than children with communicating congenital hydrocephalus, aqueductal stenosis, or other etiology. Kulkarni (2006) found that a difference of .10 or greater on the HOQ is a minimally important difference (MID), both when calculated using global health ratings and when evaluating effect sizes (Kulkarni, 2006). They asked parents and surgeons to categorize children’s levels of impairment as not at all, very mildly, mildly, moderately, severely, and very severely. The difference in HOQ scores between children scored as “not at all impaired” and “very mildly impaired” was .10. They also found that the mean difference in HOQ scores that corresponded to a moderate effect size was .09. In the development of the HOQ, children with hydrocephalus were found to have average overall scores of 0.68 and average social-emotional scores of 0.72 (Kulkarni, Drake, et al., 2004). Our sample produced average overall scores of 0.59 and average social-emotional scores of 0.65.

As hypothesized, the social-emotional domain of the HOQ correlated more highly with BASC-3 clinical scales than did other HOQ domains. Some of the BASC-3 adaptability scales (e.g., adaptability and social skills) correlated more highly with the social-emotional domain than other domains, while others (e.g., activities of daily living and functional communication) did not. Since ADLs and the ability to communicate one's needs can depend heavily on physical and cognitive functioning as well, these results were not surprising. These results support the use of the HOQ social-emotional domain to capture social-emotional and behavioral functioning in this population. Although the HOQ will not provide as much data as a full questionnaire specifically designed to measure social-emotional and behavioral functioning, having a single, short, free questionnaire that addresses multiple domains of health is important in specialized settings such as neurosurgery to ensure that other health domains are not neglected.

Limitations and Future Directions

This study is a pilot study of 30 participants from an on-going study of health status of children who received surgery for their hydrocephalus. The goal of this study was to examine how children with different etiologies of hydrocephalus compare in their social-emotional and overall functioning. The small sample size made it difficult to detect differences between etiology groups due to the large variability within groups. Much research examining functioning in children with hydrocephalus excludes some etiologies due to the heterogeneity of functioning in children with different etiologies (Burmeister et al., 2005; Hampton et al., 2013; Helder et al., 2011). Since no etiologies were excluded in this study and there were only 30 participants, we were underpowered to detect potential differences in functioning by etiology. For this study, data on functioning separated by etiology may be more useful as descriptive data. For example, the average BASC-3 internalizing composite T- score for children with an etiology of hydrocephalus due to premature birth and associated IVH is 56, while for an etiology of myelomeningocele it is 66. Although no statistically significant differences were found between etiologies, this generates a question of whether there may be clinically significant differences in emotional functioning. Future analyses will include a larger sample size that will increase statistical power to detect possible differences between etiologies.

The secondary purpose of this study was to compare the social-emotional domain of the HOQ to an established measure of social, emotional, and behavioral functioning to verify divergent and convergent validity of the 3 domains of the HOQ. In order to limit the burden on participants, only the BASC-3 was administered to compare to the HOQ but this also limits our ability to broadly confirm the validity of the HOQ. Additional studies administering other established assessments of the 3 domains of the HOQ (cognitive, physical, and social-emotional) would help bolster the validity of the HOQ. With a larger sample size, a factor analysis could also be used to confirm the domain structure of the HOQ.

Social-emotional functioning is a broad domain that can be impacted by a number of factors. In this study, only etiology was examined as a potential variable that contributes to differences in functioning in children with hydrocephalus. In future analyses we will include additional variables, such as seizure history, shunt infection history, and family income and education level. These variables were found to impact health status in other studies of outcomes in children with hydrocephalus (Kulkarni, Cochrane, McNeely, & Shams, 2008; Kulkarni &

Shams, 2007). A better understanding of the different variables that impact outcomes in this population is important for advising families and generating treatment plans that cater to a family's specific needs.

The goals of this study were to characterize the social-emotional functioning of children with different etiologies who received surgery for their hydrocephalus and to validate the social-emotional domain of the HOQ. Our results support research from other groups finding that children with hydrocephalus are at increased risk of difficulties with social and emotional functioning. We did not find differences between etiology in terms of average scores on the internalizing, externalizing, or executive functioning scales of the BASC-3 or on the HOQ social-emotional or overall scales. We observed large variability within etiology groups, indicating that variables other than etiology may contribute more to parent-report outcomes and should be explored. The social-emotional domain of the HOQ correlated more strongly with the BASC-3 than did the physical and cognitive domains, supporting the content and divergent validity of the social-emotional domain of the HOQ. Future research will examine additional variables that may impact social-emotional functioning in this population.

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Table 1

Patient characteristics

Characteristic	Value
Mean age (SD, range)	10.4 years (1.86, 8-16)
% female	27 %
Mean age at first permanent CSF diversion surgery (SD, range)	1.06 years (2.05, 1 day – 7 years)
% with etiology:	
Post-IVH second to pre.	23.3 %
Myelomeningocele	13.3 %
Comm. Congenital	20.0 %
Aqueductal Stenosis	16.7 %
Other	26.7 %

Table 2

BASC-3 scores: Children with hydrocephalus compared to normative sample

BASC-3 Scales	Patient Scores	*t*	Cohen's *d*	*p*
Internalizing Composite	58 (14)	3.15	0.58	.004*
Externalizing Composite	59 (16)	3.02	0.55	.005*
Executive Function	63 (11)	6.56	1.20	<.0001*

**p < .016, Bonferroni correction for 3 comparisons*
Note: one sample T-tests compared to BASC-3 normative sample with T-score of 50

Table 3

One-way ANOVA of BASC-3 and HOQ Scores by etiology

Scale	Etiology: Post-IVH Secondary to Prematurity *(n = 7)*	Myelo. *(n = 4)*	Comm. Congenital *(n = 6)*	Aqueductal Stenosis *(n = 5)*	Other *(n = 8)*	F	η^2	*p*
BASC-3 Internalizing*	56 (11)	66 (22)	54 (8)	56 (12)	60 (18)	0.48	.07	0.75
BASC-3 Externalizing	59 (13)	59 (13)	61 (20)	57 (15)	58 (20)	0.04	.006	1.00
BASC-3 Executive Function	67 (7)	62 (7)	64 (15)	60 (9)	62 (15)	0.33	.05	0.86
HOQ Total**	.57 (.14)	.53 (.24)	.57 (.24)	.63 (.25)	.64 (.21)	0.26	.04	0.90
HOQ Social-Emotional	.61 (.16)	.53 (.29)	.64 (.25)	.69 (.15)	.73 (.20)	0.75	.11	0.56

**BASC-3 scores have a mean of 50 and SD of 10*

***HOQ scores range from 0.0 (worse health) to 1.0 (better health) with a difference of 0.10 being clinically meaningful*

Table 4

BASC-3 scores and correlation with HOQ scores

BASC-3 Scale	Patient Scores *mean (SD)*	Pearson correlation with HOQ Physical Score	HOQ Social-Emotional Score	HOQ Cognitive Score	HOQ Overall Score
Internalizing Composite	58.03 (13.96)	.14	-.47	-.14	-.22
Externalizing Composite	58.70 (15.79)	-.25	-.46	-.35	-.42
Hyperactivity	56.33 (12.95)	-.23	-.42	-.30	-.37
Aggression	60.63 (18.55)	-.28	-.43	-.32	-.40
Conduct problems	55.40 (12.94)	-.14	-.43	-.37	-.37
Anxiety	54.73 (14.71)	.34	-.27	.01	-.003
Depression	58.60 (14.53)	.05	**-.55**	-.23	-.32
Somatization	56.63 (11.54)	-.03	-.40	-.14	-.24
Atypicality	62.83 (15.33)	-.36	**-.54**	-.30	-.47
Withdrawal	57.37 (12.82)	-.12	**-.54**	-.31	-.40
Attention Problems	60.00 (10.19)	-.23	-.43	-.51	-.45
Adaptability	45.40 (11.38)	.08	**.60**	.34	.42
Social Skills	44.50 (11.73)	.17	.48	.32	.39
Leadership	38.63 (10.85)	.47	**.54**	**.65**	**.63**
Activities of Daily Living	38.23 (10.71)	**.65**	**.67**	**.64**	**.75**
Functional Communication	38.70 (12.00)	.50	**.64**	**.68**	**.70**
Developmental Social Disorders	61.31 (12.67)	-.36	**-.65**	-.45	**-.58**
Executive Function	63.4 (11.20)	-.39	**-.65**	-.59	**-.63**

Note: correlations > .5 are bolded