Appendix

PREMORBID COGNITIVE ABILITIES 1

The running head is a shortened version of the title. It is used to help people identify titles for published research.

Estimation of Premorbid Cognitive Abilities in

Children with Traumatic Brain Injury

Graduate Student

Professor X

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The title should be centered and double spaced on the page and written in Times New Roman 12 font.

The author's name and institution should be centered and double spaced on the page.

PREMORBID COGNITIVE ABILITIES 2

Abstract

The abstract is a brief summary of the paper, highlighting the main points and purpose.

The present study will review currently available methods of estimating premorbid intellectual abilities in children, and examine the potential of the *Wechsler Intelligence Scale for Children–Fourth Edition (WISC–IV)* (Wechsler, 2003) as an estimate of premorbid IQ in children with traumatic brain injury (TBI). Archival data will be obtained from a sample of 2,200 children aged 6:0–16:11 who participated in the standardization phase of the *WISC–IV*, and 43 children aged 6:0–16:11 with a history of moderate or severe TBI who participated in a *WISC–IV* special group study. First, demographic variables including sex, ethnicity, parent education level, and geographic region will be entered into a regression analysis to determine a demographic-based premorbid prediction equation for the *WISC–IV* full scale intelligence quotient (FSIQ). Second, a logistic regression analysis will be used to investigate which *WISC–IV* subtest scaled scores improve the differential diagnosis of TBI versus a matched control group. Third, an analysis of variance (ANOVA) will be used to examine which subtests yielded the lowest mean scores for the TBI group.

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The abstract should be between 150 and 250 words in length.

Estimation of Premorbid Cognitive Abilities in Children With Traumatic Brain Injury

The title of your paper should be centered at the top of the page.

All paragraphs are indented 5 spaces.

Traumatic brain injury (TBI) is the leading cause of brain damage among children in the United States, accounting for approximately 185 to 230 cases per 100,000 children below the age of 15 (Kraus, 1995). While most childhood brain injuries are mild, 10% to 15% of this population acquires more significant injuries that result in various neuropsychological declines, including cognitive, executive, and emotional functioning (Fletcher & Levin, 1988). The cognitive profiles of these more serious injuries have been well documented and include long-term disruptions in intellectual performance, memory and attention, learning and language skills, psychomotor abilities, social judgment, behavior, academic achievement, and adaptive abilities (Barry, Taylor, Klein, & Yates, 1996; Fletcher & Levin, 1988; Taylor, Yeates, Wade, Drotar, Klein, & Stancin, 1999). Although symptoms of mild injuries may or may not be present long-term, individuals with mild brain injury have been found to exhibit emotional, cognitive, behavioral, and physical symptoms for an extended period of time (McAllister & Arciniegas, 2002).

While the outcomes of brain injury in childhood are highly variable, severity of damage has been shown to be the most important determinant of neuropsychological effects resulting from a brain lesion (Fletcher, Ewing-Cobbs, Francis, & Levin, 1995; Lezak, 1995; Taylor et al., 1999). Mild head trauma is generally associated with attention deficits, impaired verbal retrieval, and emotional distress; but moderate to severe trauma presents major problems in cognitive, emotional, and executive functioning (Lezak, 1995). Additionally, severe trauma generally requires more extensive rehabilitation, and few patients return to fully independent living. Other predictors of clinical outcomes that have been less studied in children include age at injury, preinjury abilities, familial environment, and postinjury behavioral demands (Fletcher et al., 1995).

Unfortunately, quantifying postinjury changes in the cognitive and intellectual functioning of children with TBI has not been well documented.

Preinjury assessment results are often not available, and unlike adults, estimates of premorbid functioning are difficult because children often have not achieved stable levels of functioning prior to the injury. While some researchers have attempted to develop demographic and test regression models to estimate premorbid levels of ability, underdeveloped levels of crystallized abilities in children have impeded the findings. Cognitive decline in childhood TBI has been demonstrated, but the extent of deficits is unclear.

Background of the Study

Estimation of premorbid functioning in individuals with TBI is a crucial task in the neuropsychological evaluation of cognitive decline as it provides the clinician with a baseline measure against which to compare current levels of functioning. When assessing TBI, the most common questions clinicians are concerned with include whether the injury has caused deficits in intellectual ability and, if so, what areas are affected and how severe is the decline. In the ideal situation, clinicians conduct such an assessment by evaluating the client's preinjury intellectual ability against his or her postinjury abilities (Graves, Carswell, & Snow, 1999). However, in most TBI cases, preinjury assessment is often not available and, thus, prediction estimates are frequently utilized in order to determine the severity of the damage and to make judgments about the areas affected (Snitz, Bieliauskas, Crossland, Basso, & Roper, 2000; Veiel & Koopman, 2001).

Estimates of premorbid functioning can be determined utilizing a variety of methods; the most common ones being traditional hold/don't hold tests, a combination of current test performance and observable behaviors, and demographic variables (Franzen, Burgess, & Smith–Seemiller, 1997; Graves et al., 1999; Orme, Johnstone, Hanks, & Novack, 2004). Hold/don't hold methods, which rely heavily on vocabulary and word reading abilities, have been applied almost exclusively to adults and assume that such cognitive abilities remain relatively stable despite neurological impairment (Franzen et al., 1997; Vanderploeg, Schinka, Baum, Tremont, & Mittenberg, 1998; Yeates & Taylor, 1997). The best performance method, which combines current test performance and observable behaviors, utilizes the individual's best performance or highest score across a collection of assessments, both quantitative and qualitative, as an estimate of premorbid ability (Franzen et al., 1997).

While the hold/don't hold and best performance methods are often used with adult TBI populations, both have received considerable criticism regarding the reliability and validity of utilizing specific abilities as indicators of premorbid functioning, as well as the psychometric reliability of the tests being used (Franzen et al., 1997). Because intraindividual scatter is often observed in healthy individuals and has been shown to increase as IQ increases, such methods may under- and overestimate premobid abilities for individuals who have below or above normal IQs (Barona, Reynolds, & Chastain, 1984), as well as have high standard error rates of measurements and regression to the population mean (Veiel & Koopman, 2001). Additionally, few studies have used these methods with children.

Crawford, Millar, and Milne (2001) suggest that a substitution for the hold/don't hold and best performance methods is to utilize the well-established relationship between specific demographic variables and IQ, since demographic variables remain consistent despite the effects of brain injury. Much research has been conducted providing evidence for the close association between ethnicity, socioeconomic status, education, geographic region, and scores on intelligence tests for both adults and children (Crawford, 1992; Crawford et al., 2001; Sellers, Burns, & Guyrke, 1996). In addition, studies utilizing the Wechsler scales have shown that demographic variables in regression-based prediction models have provided higher rates of interrater reliability as well as predicted a large percentage of the variance in full scale intelligence quotient (FSIQ) (Barona et al., 1984; Crawford & Allan, 1997; Wilson et al., 1978).

Statement of the Problem

Although research in the area of premorbid functioning among adult populations has had a long history, little research has been conducted with children owing to developmental and emotional factors that hinder such estimations. As Sattler (1988) notes, children's IQ levels are relatively unstable during the childhood and adolescent years owing to the influences of development, maturity, and educational attainment, making it somewhat difficult to identify powerful predictors in estimating premorbid IQ. Thus, the cognitive abilities of children and adolescents may not be fully developed prior to the brain injury. Therefore, these abilities may not be stable indicators of premorbid functioning since language skills, such as reading and listening comprehension, continue to develop throughout late childhood and adolescence (Vanderploeg et al., 1998).

Because of the limited ability to find predictive power and clinical utility in methods utilizing current test performance in children, demographic variables and demographic-based regression models have been suggested as useful estimates of premorbid abilities (Vanderploeg & Schinka, 1995). Research has indicated that demographic models may be more reliable than other methods because demographic information is not limited by postinjury changes and is not affected by developmental increases or decreases (Redfield, 2001). In a study conducted by Sellers et al. (1996), the authors found that parent education was the most reliable predictor of premorbid abilities in children, which is consistent with previous findings utilizing demographic variables in adult populations. In addition, Vanderploeg et al. (1998) found that mean parental education and child's ethnicity were the best predictors of premorbid IQ when compared with other demographic variables and combined demographic and current test performance models.

Purpose of the Study

The purpose of this study is to examine the clinical utility of using demographic variables or subtest scores of the *Wechsler Intelligence Scale for Children–Fourth Edition (WISC–IV)* (Wechsler, 2003) as a reliable estimate of premorbid functioning in children with TBI. In order to understand neurological and psychological deficits after brain injury, it is important to understand why the child is behaving in a particular way. A primary problem in establishing the presence or absence of deficits involves an inability or

Purpose statement

difficulty of measuring premorbid levels of functioning (Gagnon, Friedman, Swaine, & Forget, 2001). According to Gagnon et al., a lack of preinjury information can lead to inaccurate assessment regarding the presence and persistence of deficits, as well as a difficulty in evaluating the nature of post-injury complaints. Details about the injury, including the age at which the injury occurred, previous cognitive and psychological functioning, present functioning, and the changes that have occurred as a result of the injury, can provide the clinician with valuable information for understanding and managing the child's behavior.

Catroppa and Anderson (2003) note that severity of injury is one of the most well-established predictors of intellectual ability following brain injury among children. Such factors as preinjury levels of functioning and post-injury environment have been associated with academic and cognitive outcomes one year following brain injury (Catroppa & Anderson, 2003). As the authors note, data regarding the child's cognitive and behavioral premorbid functioning are likely to provide valuable information regarding recovery patterns and treatment recommendations.

Because demographic-based prediction models are not affected by neurological impairment or developmental changes, such methods may be supported in estimating premorbid IQ in children with TBI. Although some research has been conducted in this area, it is fairly limited, owing to the types of tests and demographic information being utilized and the evolving changes in cognitive development during childhood and adolescence. Although previous regression equations and methods for estimating premorbid IQ (which consist of demographic variables or current cognitive performance with the Wechsler scales) have not included receptive measures of intelligence, the current *WISC–IV* provides a pictorial measure of grouping similar concepts that could be considered a receptive version of the Similarities subtest. The combination of demographic variables with this measure may provide a good estimate of premorbid IQ, considering the subtest's limited demand on working memory and expressive language skills.

Research Questions

Given the limited amount of research available in the area of estimating premorbid IQ levels in children with TBI, this study is designed to test the validity and reliability of using a demographic-based model. Specifically, the study will answer the following research questions:

1. Using archival data from the *WISC–IV* (Wechsler, 2003) standardization sample (*N* = 2,200), what is the regression equation for predicting full scale intelligence quotient (FSIQ) based on the demographic variables of sex, race, parental education, and geographic region?
2. Will a subsample of the *WISC–IV* subtest scaled scores improve the differential diagnosis/prediction of traumatic brain injury (*N* = 43) versus Matched Control (*N* = 129)?
3. Compared with the demographic-based estimated FSIQ presented in question #1, which *WISC–IV* subtests display the greatest decline in mean scaled scores for the traumatic brain injury sample (*N* = 43)?

Even though this is a quantitative study, the author has included research questions. You will find research questions in most qualitative studies.

Significance of the Study

The results of this study are intended to provide empirical support for the demographic-based regression model as a reliable and valid measure of premorbid functioning in children with TBI and may have important implications for neuropsychologists, clinical psychologists, and school psychologists. Because of the limited amount of research conducted in this area and the lack of other suitable methods, studies examining the predictive validity of demographic variables among children may provide a robust method for estimating premorbid IQ. In addition, considering the prohibitive expense in money and time of a full, comprehensive cognitive assessment for school psychologists and practicing clinicians, there is a growing need to assess the utility of alternative measures. Although children may appear to recover physically, the psychological problems that result from brain injury, including deficits in the areas of behavioral, emotional, and adaptive functioning, are likely to remain.

Nature of the Study

The present study was designed to measure the effectiveness of a demographic-based regression model as an estimate of premorbid intelligence in children with TBI. Utilizing archival data from the standardization sample of the *WISC–IV*, demographic variables and scaled scores for the core and supplemental subtests were examined for 2,200 healthy children and 43 children with either open head injury or closed head injury. A matched control group of 43 children was also included.

Literature Review

Estimation of Premorbid Cognitive Functioning

Estimation of premorbid functioning is a general concern following TBI. Frequently, during diagnostic assessments and evaluations to determine head injury compensation, clinicians are asked to determine whether a client has suffered cognitive decline, the severity of the decline, and the extent of abilities affected by the injury. Because actual premorbid test scores are rarely available, clinicians are often asked to employ techniques to estimate premorbid levels of functioning in order to determine the magnitude of the damage. Whereas in severe TBI, the changes may be easier to document without recourse to preexisting test scores, individuals suffering from mild head injuries are likely to have more subtle impairments that can pose difficult challenges for clinicians.

Several methods have been developed to estimate premorbid IQ. One method for informally estimating premorbid cognitive functioning involves making a clinical judgment about the known relationships between demographic data and IQ. This method relies on the clinician's ability to gather a wide variety of data, such as demographic information, occupational history, educational records, and qualitative aspects of current test performance, and then to use this data to generate a premorbid estimate. Although this method has produced satisfactory results, it is largely dependent upon the amount of knowledge available regarding the patient's past and whether or not this information can distinguish the patient from other individuals (Lezak, 1995).

As with most methods that rely on clinical judgment, the risk of bias is high; it also assumes that clinicians have a clear understanding of the interrelationships among these variables and can reliably apply that knowledge to estimate IQ.

In response to the limitations involved in human judgment, attempts have been made to develop regression-based methods that utilize empirical data. Performance-based measures, such as the traditional hold/don't hold method and the best performance method, utilize current test performance or observable behaviors to estimate the individual's level of functioning prior to the injury. Because of criticism regarding the reliability and validity of utilizing specific abilities and test scores as indicators of premorbid functioning, demographic formulas have also been generated using only demographic variables as predictors. The demographic method proposes that demographic variables remain unchanged as a result of head injury and therefore should provide the most stable indicators of premorbid functioning. Whereas all regression-based methods have been criticized for their inaccuracies and limited ranges of prediction, the amount of research in this area has been fairly limited, especially among children. As a result, a search to examine the reliability of current estimates of premorbid IQ, as well as to provide more effective methods to predict premorbid abilities, continues.

Notice how the author introduces the literature review by outlining the various methods to estimating premorbid functioning, which will be discussed further in the literature review.

Estimation of Premorbid Cognitive Functioning in Adults

Hold/don't hold method.

The historical roots of estimating premorbid functioning in adults dates back to the mid-1950s, when Yates (1956) first introduced the idea of the hold method utilizing the Vocabulary subtest of the *Wechsler Adult Intelligence Scale (WAIS)* (Wechsler, 1955). The hold method assumes that verbal abilities remain relatively intact despite the effects of neurological impairment and that a single current vocabulary score can be representative of an individual's preinjury levels of ability. In 1958, Wechsler further defined the hold method by suggesting that there are four *WAIS* hold subtests (including Vocabulary, Information, Object Assembly, and Picture Completion) that are the most resistant to brain injury and four *WAIS* don't-hold subtests (including Block

Design, Digit Symbol, Digit Span, and Similarities) that show the most decline in functioning after brain injury, thereby creating the hold/don't hold method (Franzen et al., 1997). The hold/don't hold method is based upon Wechsler's (1958) development of a *WAIS* Deterioration Quotient, which compared verbal skills with timed subtests requiring visuospatial and motor skills.

In 1975, McFie suggested using only the *WAIS* Vocabulary and Picture Completion subtests as hold measures for predicting premorbid IQ. Similarly, Krull, Sherer, & Adams (1995) found that the Vocabulary and Picture Completion subtests of the *Wechsler Adult Intelligence Scale–Revised (WAIS–R)* (Wechsler, 1981) appeared to provide the most reliable estimates of premorbid IQ. Further research has also indicated that the *WAIS* Information and Object Assembly subtests provide reliable estimates of overall premorbid cognitive functioning due to their limited focus on memory and newly learned information, and to their placing increased weight on previously overlearned information.

Notice how the author integrates and summarizes the results of various studies.

Unfortunately, current research has shown that brain injury is likely to have adverse affects on these hold abilities, showing similar decline as with traditional don't-hold measures. As Lezak (1995) notes, verbal measures that require expressive abilities and working memory are likely to be more vulnerable to particular types of brain damage than those that are receptive in nature and require minimal memory. Additionally, while vocabulary and verbal skills may provide good estimates of premorbid IQ for specific populations, individuals with left hemisphere damage are likely to have difficulties with verbal fluency, thereby lowering scores on Vocabulary and other verbal tasks (Lezak, 1995).

It has been suggested that reading abilities may hold up better after brain damage than traditional vocabulary hold measures. As Orme et al. (2004) note, the Reading subtest of the *Wide Range Achievement Test–Third Edition (WRAT-3)* has become one of the most popular and widely used hold tests for estimating premorbid abilities because it measures basic word recognition skills. The *National Adult Reading Test–Second Edition (NART–2)* has also been identified as one of the more recent methods of estimating premorbid IQ because of its ability to measure previously learned words (Lucas, Carstairs,

& Shores, 2003) rather than analyzing complex visual stimuli (Nelson & Willison, 1991). Although reading ability is believed to remain relatively intact despite neurological impairment, results have shown that reading scores tend to underestimate premorbid ability, especially in individuals with brain injury (Morris, Wilson, Dunn, & Teasdale, 2005), Alzheimer's disease (Patterson, Graham, & Hodges, 1994), and dementia of the Alzheimer's type (Conway & O'Carroll, 1997).

Demographic-based method.

Demographic-based prediction methods were developed in response to questions about whether test score formulas could be used for predicting premorbid ability. Specifically, the demographic-based method questions several areas: the ability of subtest and test scores to correlate well with IQ, the reliability and validity of utilizing specific abilities as indicators of premorbid functioning, and the psychometric reliability of the tests being used. Because individual differences in cognitive ability vary within the general population, comparing one individual's current test score with the relevant norms of that test provides only limited and fairly unreliable information (Crawford et al., 2001). However, measures that combine demographic variables such as age, ethnicity, socioeconomic status, and education to estimate premorbid IQ avoid many of the disadvantages of the hold method, which assumes that all individuals function similarly across all areas of brain–behavior functions.

Several studies have examined the relationship between demographic variables and cognitive functioning. Research has shown that demographic variables such as socioeconomic status and education level are closely related to scores on cognitive tests and contribute significantly to variance in IQ scores (Crawford, 1992; Kaufman, 1990). Utilizing this close relationship, Wilson et al. (1978) developed the first regression equation to predict premorbid IQ using the *WAIS* standardization sample. The equation included age, sex, race, education, and occupation and accounted for 53% of the variance in the Verbal IQ, 42% of the variance in the Performance IQ, and 54% of the variance in the Full Scale IQ. Cross-validation studies have confirmed the Wilson et al.

equation to be a useful predictor of premorbid IQ. The equation has been used to predict outcome from closed head injury (Williams, Gomes, Drudge, & Kessler, 1984), to estimate British *WAIS* scores (Crawford, et al., 1989), and to estimate premorbid functioning among healthy adults (Goldstein, Gary, & Levin, 1986). Although the use and application of Wilson's formula have tended to overpredict high scores and underpredict low scores, the formula appears to make adequate predictions for those within the average range of functioning.

In an attempt to build ability estimates for the WAIS–R (Wechsler, 1981), Barona et al. (1984) developed a comparable equation using the standardization sample. Like the Wilson et al. (1978) equation, Barona et al.'s equation included sex, age, race, education, occupation, and geographic region and accounted for 38%, 24%, and 36% of the variance in the Verbal IQ, Performance IQ, and Full Scale IQ, respectively. Although the Barona et al. equation appeared to have less predictive power than the original demographic equation developed by Wilson et al., the results were consistent with previous research, identifying education level as the most powerful predictor of premorbid IQ.

As with all regression-based methods, a number of limitations are present in the use of demographic-based prediction models. As Karzmark, Heaton, Grant, and Matthews (1985) found in their use of the Wilson et al. formula to predict *WAIS* IQ scores, demographic equations tend to overestimate and underestimate IQ scores for individuals who differ by one standard deviation or more from the population mean. Although research has shown strong correlations between specific demographic variables and measured IQ scores, Bolter, Gouvier, Veneklasen, and Long (1982) found the Wilson et al. equation to be limited in its ability to predict groups of head-injured individuals and controls.

On the other hand, Wilson, Rosenbaum, and Brown (1979) compared the hold method of the Deterioration Index developed by Wechsler in 1958 against Wilson's 1978 demographic equation and found the Wilson et al. formula to have a 73% accuracy of classification, while the Wechsler method resulted in only 62% accuracy. Although the demographic-based method may have achieved mixed results at an individual level, cross-validation studies have shown it to do an adequate job of predicting mean IQ scores at the group level (Vanderploeg, 1994).

Best performance method.

More recently, researchers have attempted to increase the utility of regression-based methods by combining demographic variables with present abilities to estimate premorbid IQ in adults. The best performance method, as Lezak (1995) describes, utilizes the individual's best performance on current tests, as well as a combination of demographic variables, observed behaviors, or other reported premorbid achievements. Several studies have shown that adding current test performance to demographic regression equations improves the accuracy of estimating premorbid IQ and accounts for more variance of the actual IQ scores (Crawford, Stewart, Parker, Besson, & Cochrane, 1989; Hoofien, Vakil, & Gilboa, 2000; Vanderploeg, Schinka, & Axelrod, 1996).

In a study conducted by Crawford, Stewart, Parker et al. (1989), the authors combined current test performance on the *NART* with demographic variables, including age, sex, education, and occupation, to develop a regression equation for predicting premorbid IQ scores on the *WAIS*. The results showed that age, sex, and occupation significantly contributed to the predictive power above and beyond the *NART* scores alone and accounted for 73% of the variance in the *WAIS* Full Scale IQ, as compared with the variance of the *NART* alone (66%) and the variance of the demographic variables alone (50%). Cross-validation and construct validity studies have revealed similar results with the *NART*, with a slight drop in the amount of variance accounted for in the *WAIS* Full Scale IQ (63%), Verbal IQ (66%) and Performance IQ (38%) measures (Crawford, Cochrane, Besson, Parker, & Stewart, 1990; Crawford, Nelson, Blackmore, Cochrane, & Allen, 1990).

In 1995, Krull, Scott, and Shererr developed demographic equations that included race, education, and occupation and combined them with scores on the *WAIS–R* Vocabulary and Picture Completion subtests, known as the

Oklahoma Premorbid Intelligence Estimate (OPIE). Scott, Krull, Williamson, Adams, and Iverson (1997) used this same method, which utilized demographic variables and best performance scores, but instead included only the individual's best performance on either the Vocabulary or Picture Completion subtest, naming this method the *OPIE Best*. Both the *OPIE* and *OPIE Best* methods have been shown to highly correlate with actual IQ and to produce less under- and overestimations of premorbid abilities when compared with the *NART* alone or demographic-based methods (Scott et al., 1997).

Using a comparable method, Vanderploeg, Schinka, and Axelrod (1996) developed the *BEST-3* approach. *BEST-3* combined demographic variables, such as age, sex, race, occupation, education, urban–rural location, and geographic region with three *WAIS–R* subtests—Vocabulary, Information, and Picture Completion—to estimate premorbid IQ in brain-injured adults. The highest score predicted from the use of these three subtests, combined with the demographic variables, was used to calculate each of the *BEST-3* IQ values for Verbal IQ, Performance IQ, and Full Scale IQ. The results indicated that the *BEST-3* scores of the brain-injured group were similar to the actual IQ scores of the control group and did not over- or underestimate premorbid levels of functioning. In addition, the *BEST-3* approach obtained significantly higher correlations between actual and predicted IQ scores (FSIQ: $r = .84$; Verbal IQ: $r = .85$; Performance IQ: $r = .60$) than did the Barona et al. (1984) demographic-based equation (FSIQ: $r = .60$; Verbal IQ: $r = .62$; Performance IQ: $r = .49$).

Although the best performance method accounts for more variance in actual IQ scores and is less likely to under- or overestimate premorbid IQ, Matarazzo and Prifitera (1989) noted that a high degree of intraindividual subtest scatter is common among healthy adults. They therefore suggested that no one single subtest score can be used to predict IQ, either in combination with other variables or alone. McLean, Reynolds, and Kaufman (1990) further supported this notion, indicating that all subtest scores should be taken into account, not just the highest or lowest scores. Additional criticisms of the Best Performance approach include the reliability of the test being used and the methodology being employed.

Estimation of Premorbid Cognitive Functioning in Children

Few studies have been conducted on the estimation of premorbid IQ in children. Unfortunately, poor stability of children's IQ as a result of uneven development, maturity levels, and educational experiences have made it difficult to identify powerful predictors and have hindered such estimations. Although adult IQ is assumed to be fairly stable, children's IQ levels have been found to be relatively unstable due to underdeveloped crystallized abilities and changes in IQ development. Because pre-injury ability data are often not available and retrospective data are frequently limited, information regarding pre-injury performance is not always accurate and does not reliably estimate the child's preinjury functioning.

The first equation for predicting premorbid IQ in children was introduced in 1979 by Reynolds and Gutkin. In their study, the authors used demographic variables to develop prediction formulas on the *WISC–R* standardization sample. The equations only moderately correlated with the *WISC–R* verbal intelligence quotient (VIQ), performance intelligence quotient (PIQ), and full scale intelligence quotient (FSIQ). However, Vanderploeg, Schinka, Baum et al. (1998) found in a later study using *WISC–III* that such demographic variables highly correlated with the three indices and that mean parental education and ethnicity were the strongest predictors.

Receptive measures of vocabulary, which do not require any verbal output and do not place a high demand on working memory skills, have been shown to be good estimates of premorbid IQ in children. As Moran and Gillon (2004) found in their assessment of the language and memory profiles of adolescents with brain injuries, adolescents performed best on the *Peabody Picture Vocabulary Test–Third Edition* (Dunn, Dunn, & Williams, 1997) due to its limited focus on working memory requirements, which are associated with listening and reading comprehension skills. Furthermore, Snitz et al. (2000) demonstrated that the *Peabody Picture Vocabulary Test–Revised* (Dunn & Dunn, 1981) accurately estimated premorbid IQ in individuals with more than 13 years of education; however, in individuals with less than 13 years of schooling, the Barona et al. equation proved to be more stable.

As with other prediction methods, both demographic-based regression models and demographic-plus-subtest methods have been criticized on their ability to accurately predict premorbid IQ. While some formulas have shown fairly good reliability in their estimates, others have shown elevated or lowered estimated scores for individuals who have premorbid IQ scores above 120 or below 69 (Barona et al., 1984). However, at a group level, Vanderploeg, Schinka, and Axelrod (1996) noted that demographic-based regression equations appear to produce fairly precise results for predicting mean IQ scores among children with brain injuries.

In addition, in a study conducted by Crawford, Stewart, Parker et al. (1989), the authors found that demographic variables contributed more significantly to the predictive power of premorbid IQ than did current ability measures. Furthermore, O'Grady (2003) found that, among children treated for medulloblastoma, demographic-based prediction methods provided the most valid estimate for assessing premorbid IQ, whereas the addition of *WISC–III* subtests consistently underestimated FSIQ when compared with individuals without brain injury.

Method

Given the lack of research into estimating premorbid IQ levels in children with TBI, this research study was designed to test the validity and reliability of using a demographic-based model and examine whether specific subtest scores improve the prediction of TBI. Specifically, the study will answer the following research questions:

1. Using archival data from the *WISC–IV* standardization sample (*N* = 2,200), what is the regression equation for predicting FSIQ based on the demographic variables of sex, race, parental education, and geographic region?
2. Will a subsample of the *WISC–IV* subtest scaled scores improve the differential diagnosis/prediction of traumatic brain injury (*N* = 43) versus matched control (*N* = 129)?
3. Compared with the demographic-based estimated FSIQ presented in question #1, which *WISC–IV* subtests display the greatest decline in mean scaled scores for the traumatic brain injury sample (*N* = 43)?

In order to evaluate the validity and reliability of using a demographic-based model and to examine whether specific subtest scores improve the prediction of TBI, the following alternate hypotheses were tested:

1. Parental education will be the best predictor of FSIQ.
2. Based on previous research with the *WISC–III*, a subset of *WISC–IV* subtests will improve the prediction of TBI group membership.
3. Individuals with TBI will have lower scores on the Processing Speed Index (i.e., the Coding, Symbol Search, and Cancellation subtests) and Working Memory Index (i.e., the Digit Span, Letter–Number Sequencing, and Arithmetic subtests), and there will be no differences in index and subtest scores in the matched control group.

The Null Hypotheses, unless refuted, suggest the following:

1. Sex, race, parental education, and geographic region will not significantly contribute individually or in combination to predicting

FSIQ.

2. No *WISC–IV* subtest scaled scores will significantly improve the prediction of TBI group membership.
3. There will be no differences in subtest scaled score declines when compared with the demographic-based estimated FSIQ for the TBI sample.

Research Methodology

The present study uses a correlational design with an archival data-based quantitative methodology. The study will involve the use of *WISC–IV* standardization data and *WISC–IV* clinical group data to develop a demographic-based regression equation for predicting premorbid IQ, in addition to analyzing which *WISC–IV* subtests, if any, will improve the prediction of TBI group membership. Because this researcher will use archival data, the independent variables (including demographic factors and subtest scaled scores) cannot be manipulated. According to Kazdin (1992), correlational research designs are used when the relationships among variables are observed but the independent variables cannot be experimentally manipulated. Such designs are often necessary when experimental designs cannot be carried out due to ethical or practical reasons, and are frequently used when evaluating psychological assessments and individual differences (Goodwin, 1998).

Notice how the author includes the research methodology and design.

Target Population

The participants or target population will consist of 2,200 children aged 6:0–16:11 who participated in the *WISC–IV* standardization project. In addition, 43 children aged 6:0–16:11 with TBI who participated in the *WISC–IV* special group study and 129 matched control children who participated in the *WISC–IV* standardization project will be used. Of the 43 participants diagnosed with TBI, 16 children had been diagnosed with open head injury and 27 children with closed head injury. One hundred and twenty-nine children with no clinical diagnoses from the *WISC–IV* standardization sample will make up the matched control group, which are matched to the clinical TBI group on the variables of age, sex, and ethnicity.

Data Collection

Invitations to participate in the *WISC–IV* standardization were mailed to school districts in the United States during the winter of 2002. School districts were selected on the basis of their urban–rural classification, socioeconomic status, and racial/ethnic composition. In addition, several other sites were located to complete the sample and to collect specific validity and clinical data.

Informed consent was obtained by all participants for the *WISC–IV* standardization project. Informed consent was required to ensure that participants fully understood and agreed to Harcourt Assessment, Inc., not providing feedback regarding their child's performance. Furthermore, written permission was obtained to publication of the data, as well as to the use of the data for other professional purposes, so long as the names, IDs, and other identifying information would be kept confidential.

For each participant, the following information was obtained from a consent form and a clinical diagnostic information form: demographic characteristics, including the child's age, sex, and race/ethnicity; parental level of education and occupation; historical and present diagnoses based upon the *Diagnostic and Statistical Manual of Mental Disorders–Fourth Edition, Text Revision (DSM-IV-TR*) (American Psychiatric Association, 2000); and intelligence or achievement scores, as well as scores on specific clinical diagnostic assessments.

A stratified random sampling approach was used to select children representative of the population based on the 2000 U.S. Census. Both the standardization and TBI samples were stratified by age, race/ethnicity, and sex to represent the U.S. Census data as closely as possible. Each examinee was assigned to an examiner who had experience in giving individually administered tests and who demonstrated proficiency in administering the *WISC–IV*.

The TBI group consisted of children diagnosed with traumatic brain injury between the ages of 6 and 16 who had been identified with a history of moderate to severe TBI. Children with previous histories of a mild TBI were also included if CT or MRI abnormalities were noted in the medical history. Children who sustained a TBI within 6 months prior to the time of testing were excluded, as well as those with estimated or measured intelligence in the range expected for mental retardation. Inclusion criteria included the following: (1) having existing scores of ≥60 on a standardized measure of cognitive ability; (2) premorbid or estimated premorbid IQ scores of >70; (3) duration of impaired consciousness at the time of injury between 1 and 24 hours; (4) no diagnosis of a psychiatric disorder evident prior to the injury; (5) the injury not due to a tumor or other medical illness; (6) and no experience of posttraumatic amnesia at the time of testing (Wechsler, 2003).

The matched control group was selected based on characteristics such as age, sex, and ethnicity, which closely matched the TBI group. The matched control group, which consisted of children between the ages of 6 and 16 years, were selected based on the following criteria: (1) primary language spoken is English; (2) the ability to communicate verbally is at a level consistent with his/her age, and not primarily nonverbal or uncommunicative; (3) has normal hearing and vision (with or without aid) and normal fine and gross motor ability; (4) has no physical conditions, illnesses, or impairments that would affect performance; (5) is not currently taking medication that might depress performance; (6) does not have a diagnosis of pervasive developmental disorder, TBI, or psychiatric disorder; (7) is not currently admitted to a hospital, mental, or psychiatric facility; (8) does not have a diagnosis of a seizure disorder, or history of a seizures, epilepsy, encephalitis, brain surgery, or a period of unconsciousness lasting 5 or more minutes; and (9) has not been tested on any intelligence measure in the previous 6 months.

Data from the demographic information forms were organized using a data sheet containing the following categories: age, sex, ethnicity/race, parent education level, and region. Subtypes of the categories were coded as follows:

Age. Ages of children were coded according to the *WISC–IV* standardization sample as follows: 1 = 6:0–6:11; 2 = 7:0–17:11; 3 = 8:0–8:11; 4

= 9:0–9:11; 5 = 10:0–10:11; 6 = 11:0–11:11; 7 = 12:0–12:11; 8 = 13:0–13:11; 9 = 14:0–14:11; 10 = 15:0–15:11; 11 = 16:0–16:11.

Sex. Sex was coded according to the *WISC–IV* standardization sample as follows: 1 = male; 2 = female.

Ethnicity/Race. Ethnicity/race of children was coded according to the *WISC–IV* standardization sample and March 2000 U.S. Census data as follows: 1 = European American; 2 = African American; 3 = Hispanic; 4 = Asian American; 5 = Other.

Parent Education Level. Parent education level was coded according to the *WISC–IV* standardization sample as follows: 1 = 0–8 years; 2 = 9–11 years; 3 = 12 years (high school degree or equivalent); 4 = 13–15 years (some college or associate's degree); 5 = 16+ years (college or graduate degree).

Geographic Region. Geographic region was coded according to the *WISC–IV* standardization sample as follows: 1 = Northeast (i.e., Rhode Island, Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, Pennsylvania, New Jersey); 2 = South (i.e., Texas, Oklahoma, Arkansas, Louisiana, Mississippi, Alabama, Georgia, Florida, South Carolina, North Carolina, Tennessee, Kentucky, Virginia, West Virginia, Maryland, Delaware, District of Columbia); 3 = West (i.e., New Mexico, Colorado, Wyoming, Montana, Idaho, Utah, Arizona, Nevada, Washington, Oregon, California, Alaska, Hawaii); and 4 = Midwest (i.e., Kansas, Missouri, Illinois, Indiana, Ohio, Nebraska, South Dakota, North Dakota, Minnesota, Iowa, Wisconsin, Michigan).

Instrumentation

The *WISC–IV* was used to assess the FSIQ of each participant. The *WISC–IV* has been standardized for use with children 6–16 years of age. It contains a total of 16 subtests, divided into four factor-based index scores: the Verbal Comprehension Index, Perceptual Reasoning Index, Working Memory Index, and Processing Speed Index. Performance on the various measures is summarized in five composite scores: the Verbal Comprehension, Perceptual Reasoning, Working Memory, Processing Speed, and Full Scale IQs. The factor-based indices, as well as the IQ scales, have a mean of 100 and standard deviation of 15. A description of each of the *WISC–IV* subtests is provided in Appendix A.

If you include an Appendix, be sure to indicate that within your paper.

Scaled scores for each subtest on the *WISC–IV*, in addition to Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed index scores and Full Scale IQ scores were obtained through archival data provided by Harcourt Assessment, Inc.

Data Analysis

The data will be analyzed by the 21.0 version of the Statistical Package for the Social Sciences (SPSS). The standardization and TBI group participants will be numbered consecutively from 0001 to 2,243. Numbers observed for categories and subtypes will be computed.

To investigate the first research question (Using the *WISC–IV* Standardization sample, what is the regression equation for predicting FSIQ based on the demographic variables of sex, race, parental education, and geographic region?), a multiple regression model will be used to determine which predictor or independent demographic variables (sex, ethnicity/race, parental education, and geographic region) significantly contribute individually or in combination to the dependent variable: predicted FSIQ. According to Goodwin (1998), multiple regression analyses are used when the researcher wishes to examine the relationships between a criterion variable and several predictor variables, allowing an investigation of which variables are predictors and the relative strengths of their predictions. An advantage of conducting multiple regression analyses is that one can examine the combined influences of several predictor variables rather than the influence of one predictor variable by itself (Goodwin).

To examine the second research question (Will a subsample of the *WISC–IV* subtest scaled scores improve the differential diagnosis/prediction of TBI [$N = 43$] versus matched control [$N = 129$]?), a backward elimination logistic regression model will be used to predict the outcome or dependent variable, group membership (TBI versus matched control), based on the independent variable, the 16 *WISC–IV* subtest scores. Logistic regression is used when predicting a discrete outcome, such as group membership, from a set of variables that may be interval, nominal, or a mix.

Finally, to investigate research question three (Compared with the demographic-based estimated FSIQ presented in question #1, which *WISC–IV* subtests display the greatest decline in mean scaled scores for the TBI sample [$N = 43$]?), within subjects, ANOVA tests and Bonferroni post hoc tests will be used to assess differences in mean decline across the subtests.

Discussion

Depending upon the institution's requirements, there may or may not be a Discussion section included in the research proposal.

Clinical Applications/Strengths

The results of this study will provide empirical support for the clinical utility and limitations of demographic-based methods and current test performance techniques to generate estimates of premorbid IQ levels in children with TBI. Although research in the area of estimating premorbid intelligence in children is limited and has produced somewhat unstable results due to this age group's growth changes in development and maturity, the findings from this study will emphasize the need to identify reliable prediction strategies in order to accurately assess the effects of brain injury. Prediction of premorbid functioning is critical to understanding the consequences of childhood TBI and to gauging the magnitude of impairment.

Although the most reliable means of estimating premorbid functioning would be to collect information retrospectively from previous test scores or other indicators of cognitive ability, in most childhood TBI cases, pre-injury information is often not available. Therefore, contemporary research has begun to focus its efforts on finding prediction strategies that can provide useful information about the severity of the damage and the affected areas (Snitz et al., 2000; Veiel & Koopman, 2001). As Donders and Strom (2000) note, comparisons of pre- and post-injury functioning provide crucial information for clinicians, educators, and family members to identify the child's strengths and weaknesses. In contrast, interpreting a cognitive profile without a full understanding of the child's premorbid history and premorbid levels of functioning could result in an inaccurate representation of the cause of deficit, an inaccurate portrayal of the areas affected, an incorrect understanding of the child's behavior, a poor prediction regarding the course of recovery, and inappropriate treatment for the presenting problems.

Thus, findings from this study will have important implications for neuropsychologists, clinical psychologists, and school psychologists. Due to the limited amount of research conducted in this area and the lack of other suitable methods, studies such as this one, which examine the predictive validity of utilizing demographic variables or current performance measures among children, may provide a robust method for estimating premorbid IQ. In addition, considering the prohibitive costs and time it would take for school psychologists and practicing clinicians to administer a full, comprehensive cognitive assessment, there is a growing need to assess the utility of such alternative measures. Although children may appear to recover physically, the psychological problems that result from brain injury, including deficits in the areas of behavioral, emotional, and adaptive functioning, are likely to remain. Data regarding the child's cognitive and behavioral premorbid functioning are likely to provide valuable information regarding recovery patterns and treatment recommendations.

Limitations

A delimitation the researcher may have is that the results may not be valid in children of all ages. Research has suggested that developing cognitive abilities in children may serve as confounding variables when investigating premorbid IQ levels and current functioning (Vanderplog et al., 1998). In addition, because the *WISC–IV* would not have been administered to individuals pre-injury, a post-injury-only assessment will have to be used. It is likely that post-injury assessments, such as applying demographic premorbid estimation equations, may have limitations with respect to under- and over-estimating previous levels of functioning.

Furthermore, because the TBI data were based on availability rather than on random selection, it is likely that the population selected is not representative of the entire TBI population. Considering the difficulty in obtaining a TBI group sample, the small sample size is assumed to be adequate for this study, although the results are likely to be restrictive.

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Appendix A

Description of *WISC–IV* Subtests

Block Design	The child views a constructed model or a picture in the Stimulus Book, and uses red-and-white blocks to re-create the design within a specified time limit.
Similarities	The child is presented two words that represent common objects or concepts and describes how they are similar.
Digit Span	The Digit Span subtest is composed of two parts: Digit Span Forward and Digit Span Backward. For Digit Span Forward, the child repeats numbers in the same order as read aloud by the examiner. For Digit Span Backward, the child repeats the numbers in the reverse order of that presented by the examiner.
Picture Concepts	For each item, the child is presented with two or three rows of pictures and chooses one picture from each row to form a group with a common characteristic.
Coding	The child copies symbols that are paired with simple geometric shapes or numbers. Using a key, the child draws each symbol in its corresponding shape or box within a specified time limit.
Vocabulary	For picture items, the child names pictures that are displayed in the Stimulus Book. For verbal items, the child gives definitions for words that the examiner reads aloud.

Appendix A *Cont.*

Description of *WISC–IV* Subtests

Letter–Number Sequencing	The child is read a sequence of numbers and letters and recalls the numbers in ascending order and the letters in alphabetical order.
Matrix Reasoning	For each item, the child looks at an incomplete matrix and selects the missing portion from five response options.
Comprehension	The child answers questions based on his or her understanding of general principals and social situations.
Symbol Search	The child scans a search group and indicates whether the target symbol(s) matches any of the symbols in the search group within a specified time limit.
Picture Completion	The child views a picture and then points to or names the important part missing within a specified time limit.
Cancellation	The child scans both a random and structured arrangement of pictures and marks target pictures within a specified time limit.
Information	The child answers questions that address a broad range of general knowledge topics.
Arithmetic	The child mentally solves a series of orally presented arithmetic problems within a specified time limit.
Word Reasoning	The child identifies the common concept being described in a series of verbal clues.