Executive Functioning in Persons Undergoing Hemodialysis

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EXECUTIVE FUNCTIONING IN PERSONS UNDERGOING HEMODIALYSIS

By Alexandria DiGuisepppe

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ABSTRACT

Chronic kidney disease (CKD) is a condition in which damaged kidneys cannot properly filter blood throughout the body. This results in excess fluid and waste products to remain in the bloodstream, which can lead to other health complications if not treated. Kidney failure occurs when an individual has 10-15% of optimal kidney functioning, resulting in toxic levels of waste in the bloodstream. Recent literature has demonstrated that individuals receiving dialysis have poorer cognitive functioning compared to the general population, especially in regard to executive functioning. The purpose of the current study was to identify the executive functioning abilities in a sample of kidney dialysis patients and to determine the feasibility of conducting neuropsychological assessments within a dialysis clinic setting. Preliminary data from a small sample revealed that, overall, participants did not demonstrate clinically significant deficits in subjective or objective executive functioning abilities. However, two clinically noteworthy profiles were analyzed. Findings also suggested that the use of the BRIEF-A and the TMT, Parts A and B, are feasible and useful within a dialysis clinic. Clinical implications are discussed and include the need for a behavioral health presence in dialysis clinics and routine neuropsychological testing. Additional implications regarding the impact of cognitive impairment on medical adherence are also discussed.
CHAPTER 1: INTRODUCTION

Statement of the Problem

Chronic kidney disease (CKD) is a condition in which damaged kidneys cannot properly filter blood throughout the body. This results in excess fluid and waste products to remain in the bloodstream, which can lead to other health complications if not treated (Center for Disease Control, 2017). According to the Center for Disease Control (CDC), it is estimated that approximately 30 million adults in the United States are diagnosed with this disease (CDC, 2017). For those individuals living with CKD, their prognosis is generally expected to worsen over time and, in many cases, results in kidney failure. Kidney failure occurs when an individual has 10-15% of optimal kidney functioning, resulting in toxic levels of waste in the bloodstream (National Kidney Foundation, 2017). Therefore, dialysis (e.g., hemodialysis, peritoneal dialysis) is often necessary to slow the progression of the disease and improve survival (CDC, 2017). When kidney failure is treated with dialysis, the condition is then referred to as end-stage renal disease (ESRD).

Recent literature has examined the effect of dialysis on cognitive functioning among individuals living with ESRD (Henry, Jamner, Choi, & Pahl, 2018). This growing body of research has demonstrated that individuals who are treated with dialysis have poorer cognitive functioning compared to the general population, especially in regard to attentional processes and orientation (O’Lone et al., 2016). It is theorized that the process of undergoing dialysis directly contributes to this diminished cognitive functioning (Henry et al., 2018). For example, the toxicity theory of cognitive functioning suggests that the volumetric increase in fluid between dialysis treatments leads to shifts in cognitive abilities and that the build-up of waste products
and minerals leads to confusion and overall cognitive impairment (Henry et al., 2018). Therefore, this theory supports the notion that dialysis patients will experience improvements in cognitive functioning after receiving hemodialysis due to the elimination of waste throughout the body. In contrast, the osmotic theory of cognitive functioning postulates that cognitive functioning is influenced by the shift in fluid and solute levels from the pre-to-post dialytic state. Therefore, cognitive functioning is believed to improve as time passes since receiving dialysis and be more impaired during and shortly after receiving dialysis (Henry et al., 2018). In addition to the effect of dialysis, researchers have also begun to examine the impact of comorbid medical conditions on cognitive functioning, particularly cardiovascular disease in patients with ESRD (Sarnak et al., 2013). For example, a growing body of literature suggests that hemodialysis patients with comorbid cardiovascular disease have less well-developed processing speed and executive functioning abilities compared to healthy individuals (Weiner et al., 2011). Similarly, it was noted that lower executive functioning abilities are positively associated with cardiovascular disease in this population (Sarnak et al., 2013).

Given this information, research is needed to further explore the level of executive functioning that exists among patients with ESRD receiving dialysis. It is particularly important to better understand how the direct impact of dialysis treatment impacts cognitive functioning among these patients. Research should also aim to demonstrate that cognitive deficits in dialysis patients may present differently (e.g., more impaired) compared to the normal aging process. Further, research should also more closely examine how these cognitive deficits impact medical adherence and the impact this has on health outcomes. As previous research has suggested, decreased cognitive functioning contributes to complications in carrying out health related
behaviors (Schnieder et al., 2015). Executive functioning, in particular, is critical in managing these behaviors. Therefore, deficits in this area may contribute to problematic behaviors (e.g., decreased medication management) among dialysis patients (CDC, 2017). This body of literature warrants continued exploration of the impact of dialysis on executive functioning skills and how this decline relates to medical adherence among ESRD patients.

While there is burgeoning literature that examines the relationship between dialysis and cognitive functioning, additional research is needed to better understand this relationship. Existing studies have assessed cognitive functioning during the interdialytic interval (i.e., time between receiving dialysis treatments; Dixit et al., 2013; Odagiri et al., 2011); however, more literature is needed to examine patients’ level of cognitive functioning while actively receiving dialysis treatments. Prior research has suggested that the effectiveness of interventions can be accelerated with the use of feasibility and pilot studies (Tickle-Degnen, 2013). According to The British National Institute for Health Research’s Evaluation, feasibility studies specifically focus on examining whether a study “can be done” and are initially conducted to assess the research and intervention process. As such, while there are limited studies that assess cognitive functioning during dialysis treatments, the feasibility of administering neurocognitive assessments to dialysis patients within a dialysis clinic is warranted.

**Purpose of the Study**

Existing literature has reliably demonstrated that patients living with end-stage renal disease (ESRD) experience decreased cognitive functioning compared to the general population, especially in executive functioning abilities (O’Lone et al., 2016). Cognitive deficits in the areas of orientation and awareness are most commonly observed in this population. To better
understand this relationship, recent literature has begun to study the relationship between dialysis (i.e., hemodialysis, peritoneal dialysis) and cognitive functioning among these patients (Neumann et al., 2017). The purpose of the current study was to identify the executive functioning abilities in a sample of patients receiving kidney dialysis and compare their performance to the normative sample of healthy adults. The purpose of the current study was to also examine the feasibility of conducting neuropsychological assessments in a kidney dialysis clinic. Specific areas that were examined included cost of materials, level of training required for test administration, and ease of administration, among others. The current study ultimately provides information regarding dialysis patients’ higher order thinking skills, which are imperative for managing medications, scheduling and attending dialysis sessions, and adhering to dietary restrictions, among other complex tasks.

Research Questions and Hypotheses

The first research question asks: Do patients receiving kidney dialysis demonstrate executive functioning skills comparable to the normative data of healthy individuals with similar age, sex, ethnicity, and level of education? The second research question asks: Is it feasible to conduct neuropsychological assessments in a kidney dialysis clinic?

Hypothesis 1: It was hypothesized that patients receiving kidney dialysis would demonstrate impaired abilities in executive functioning in comparison to normative scores as measured by the BRIEF-A and the Trail Making Test, Part A and B (TMT, Parts A and B). This hypothesis was supported by a growing body of literature that has demonstrated the executive functioning deficits that exist among this population (O’Lone et al., 2016). Further, research has also shown that these cognitive deficits are unique to receiving dialysis treatments and are not solely due to the normal aging process. By comparing scores of executive functioning to the
normative scores, this hypothesis aligns with previous findings (O’Lone et al., 2016). Executive functioning was measured via the BRIEF-A and the TMT, Parts A and B, which provided both a subjective and objective measure of executive functioning abilities. “Impaired” executive functioning was measured via normative $T$-score cut-offs that are respective to both the BRIEF-A and TMT, Parts A and B.

Hypothesis 2: It was hypothesized that conducting neuropsychological assessments, especially those focusing on executive functioning abilities, would be feasible and useful within a kidney dialysis clinic setting. This hypothesis was supported by a growing body of literature that has examined the successful use of neuropsychological assessments among dialysis patients (Dixit et al., 2013). Research has also suggested that dialysis patients demonstrate poorer executive functioning abilities compared to the general population (O’Lone et al., 2016). As such, this has been shown to lead to decreased medical adherence, as patients may experience challenges associated with their medical regimen (e.g., medication management and dietary restrictions; Schnieder et al., 2015). While there is a paucity of research in these areas, a better understanding of the feasibility of conducting neuropsychological assessments among dialysis patients is clinically warranted.
CHAPTER 2: REVIEW OF THE LITERATURE

According to the CDC, CKD is a condition in which unhealthy kidneys are not able to properly filter blood throughout the body. This lack of filtration causes excess fluid and waste products to remain in the body, which can lead to other health complications, such as cardiovascular disease (CDC, 2017). As of 2017, it was estimated that approximately 30 million adults in the United States have been diagnosed with CKD (CDC, 2017). Demographically, this disease occurs more frequently in women and African Americans, compared to men and Caucasians, respectively. Individuals with CKD are also likely to develop worsening symptoms over a period of many years. Advanced cases of this disease commonly result in kidney failure, which is defined as having only 10-15% of optimal kidney functioning (United States Renal System Data, 2018). Kidney failure requires either dialysis treatment or kidney transplantation for survival. When these interventions are needed, the disease is then referred to as end-stage renal disease (ESRD; United States Renal System Data, 2018). In 2010, it was estimated that approximately 408,000 individuals in the United States were living on dialysis (United States Renal System Data, 2018). Recent literature has also shown that nearly half of new dialysis cases belong to a racial or ethnic minority group in the United States (Burros et al., 2014). Individuals living with ESRD also have a significantly higher likelihood of developing other health complications, compared to healthy individuals (Helou et al., 2016). Common health complications include diabetes mellitus and cardiovascular disease (Bahatti et al., 2016; Helou et al., 2016). Approximately half of individuals with CKD or ESRD also live with diabetes mellitus (National Institute of Diabetes and Digestive and Kidney Diseases, 2018). Further, it has been reported that diabetes mellitus is
the most common cause of ESRD and is an important risk factor for cardiovascular disease (National Institute of Diabetes and Digestive and Kidney Diseases, 2018). In addition to comorbid health conditions, patients receiving kidney dialysis are also at a higher risk for experiencing cognitive impairment, compared to the general population (Harciarek et al., 2016). Recent research has demonstrated that individuals treated by hemodialysis, the most common form of dialysis treatment among ESRD patients, performed significantly lower in areas of orientation and attention, including skills such as processing speed and working memory (O’Lone et al., 2016). Various theories have been postulated regarding cognitive decline in this population. Research has specifically focused on the effect of interdialytic intervals and toxic build-up in the body on cognitive functioning in hemodialysis patients (Henry et al., 2018). Such theories suggest that increased toxicity levels (e.g., build-up of minerals in the body) in between dialysis treatments contributes to cognitive impairment (Henry et al., 2018). Due to the paucity of literature focusing on cognitive decline in kidney dialysis patients, further exploration in this area is warranted. Specific attention should be given to the impact of increased toxicity as it relates to specific areas of cognitive decline, such as executive functioning abilities. Additionally, executive functioning as it relates to patients’ medical adherence should be investigated, as research has suggested that there is an association between the effect of dialysis treatment on decreased attention and orientation (O’Lone et al., 2016). These cognitive abilities are essential to performing complex tasks and, therefore, may be associated with challenges relating to medical adherence (e.g., medication management) (Schnieder et al., 2015).
Chronic Kidney Disease

An individual is diagnosed with CKD if abnormalities of kidney function or structure have been present for more than three months (The Renal Association, 2019). The medical definition of CKD includes those individuals with marked kidney damage, including albuminuria (i.e., protein in the urine), haematuria (i.e., blood in the urine), structural abnormalities of the kidneys, or a history of kidney transplantation (The Renal Association, 2019). CKD is also identified if individuals have a glomerular filtration rate (eGFR) level that is less than 60mL per minute on two or more occasions that are 90 days apart. The value of the eGFR measures the rate at which the kidneys filter waste products from the bloodstream in milliliters per minute, and is calculated from a blood creatinine test, age, body size, and gender (National Kidney Foundation, 2018). Therefore, a low eGFR indicates decreased kidney functioning, which causes a lack of filtered waste products from exiting the body (The Renal Association, 2019).

Patients with CKD are classified depending on their level of kidney function via their eGFR, and the presence of proteinuria, which is abnormal protein levels in the urine (The Renal Association, 2019). Thus, the eGFR and proteinuria levels directly speak to the progression, or stages, of CKD. Stage 1 of CKD involves kidney damage with normal kidney function, with an estimated eGFR that is greater than 90 mL with persistent proteinuria for three months or more. Stage 2 involves kidney damage with mild loss of kidney function, with an estimated eGFR that is between 60 to 89 mL with persistent proteinuria for three months or more. Stage 3 involves mild to severe loss of kidney function, with an estimated eGFR of 30-59 mL, and stage 4 involves severe loss of kidney functioning with an estimated eGFR of 15-29 mL. Lastly, stage 5 involves complete kidney failure, requiring dialysis or kidney transplantation for survival. Once the
severity of CKD has progressed to stage 5, the individual is then diagnosed with ESRD (CDC, 2017).

According to the CDC (2017), there have been approximately 21,000 new cases of ESRD each year since 2010. In early 2013, it was reported that 88% of affected individuals initiated renal replacement therapy via hemodialysis, 9% initiated peritoneal dialysis, and only 2.6% of cases received a kidney transplant (CDC, 2017). By the end of 2013, the percentage of kidney transplantations increased to 29.2%, which caused a decrease in hemodialysis and peritoneal dialysis rates (63.7% and 6.8%, respectively; CDC, 2017). Demographically, African Americans are approximately 3.5 times more likely to develop ESRD compared to Caucasians in the United States. Similarly, Hispanics are approximately 1.5 times more likely to develop ESRD compared to non-Hispanics (CDC, 2017). Due to the chronic nature of this disease, literature has given attention to the clinical implications of ESRD for patients receiving intensive replacement therapies (e.g., hemodialysis). Recently, researchers have found that there is an increased rate of anxiety and stress among individuals living with ESRD (Zamanian et al., 2018). Further results also suggest that, due to increased psychological distress coupled with the intensity of replacement therapy, quality of life has significantly decreased in this population (Zamanian et al., 2018). In addition to decreased mental health, patients with ESRD are also at risk for developing other health conditions, which has been shown to directly impact their overall prognosis throughout treatment (Kim et al., 2011).

**Health Conditions Associated with End-Stage Renal Disease**

A large body of literature shows that ESRD is highly comorbid with diabetes mellitus and cardiovascular disease (Bahatti et al., 2016; Marshall, 2014). Such health conditions are
important to consider for patients with ESRD, as proper treatment of these health conditions may impact their prognosis of ESRD and overall survival (Marshall, 2014). Current research has examined the psychological and cognitive impact of these comorbid health conditions and ESRD. For example, researchers have suggested that individuals with comorbid diabetes and ESRD have a greater risk for experiencing anxiety and depression (Yoong et al., 2017). Further, individuals with cardiovascular disease and ESRD have been shown to demonstrate cognitive impairment compared to their healthy counterparts (Weiner et al., 2011). Given that diabetes and cardiovascular disease have a large impact on the overall functioning of individuals with ESRD, these health conditions are important to consider when treating these individuals.

**Diabetes Mellitus**

In 2014, 120,000 individuals in the United States and Puerto Rico began treatment for ESRD (CDC, 2018). It was reported that diabetes was the primary cause of ESRD in approximately 44% of these cases (CDC, 2017). Recent analysis from the U.S. Renal Data System (2018) has shown that the incidence rates of comorbid ESRD and diabetes (ESRD-D) has declined since 1980. However, newly diagnosed ESRD-D cases are expected to increase, as the number of individuals with diabetes increases (CDC, 2017). Research has shown that one in three adults with diabetes is likely to also have CKD. However, many of these individuals living with diabetes are not aware that they are living with CKD (CDC, 2017). Further, diabetes increases the risk of moderate to severe CKD, and is reported to be the most common cause of ESRD (Marshall, 2014). Recent literature has also shown that patients with diabetes and ESRD have increased rates of comorbid health conditions, such as cardiovascular disease, and demonstrate poorer prognosis compared to patients without these comorbidities (Rhee et al.,
Further, researchers have also suggested that renal insufficiency, when coupled with diabetes, is highly associated with major adverse cardiac events, such as acute myocardial infarctions (Kim et al., 2011).

**Cardiovascular Disease**

The comorbid nature of diabetes and ESRD has been established as an important risk factor for cardiovascular disease (Kim et al., 2011). The National Institute of Diabetes and Digestive and Kidney Diseases (2018) reported that 69.6% of individuals who are diagnosed with cardiovascular disease also live with chronic kidney disease. Further, cardiovascular disease is considered the most common cause of death and accounts for approximately 53% of deaths among patients diagnosed with ESRD (Bhatti et al., 2016). The physiological progression of cardiovascular disease in CKD cases involves accelerated atherosclerosis and reduced left ventricular function, due to declined renal function (Hage et al., 2009). Coronary artery disease (CAD) is considered to be the most prevalent type of cardiovascular disease in individuals with ESRD (Bhatti et al., 2016). Increased prevalence rates of CAD are due to the presence of other health conditions such as diabetes, hypertension, and obesity in this population (Foley et al., 1995). Further, atherosclerotic heart disease is considered the disease that is most frequently linked to CKD, accounting for 40% of cases in individuals ages 66 and older (CDC, 2017). In patients diagnosed with ESRD, acute myocardial infarctions, atherosclerotic heart disease, congestive heart failure, and cerebrovascular accidents accounted for more than 50% of the causes of death between 2012 and 2014 (CDC, 2017).
Treatment Options for End-Stage Renal Disease

The available treatment options for individuals who need renal replacement therapy include hemodialysis, peritoneal dialysis, and kidney transplantation (CDC, 2017). To date, hemodialysis is the most common form of dialysis in the United States (National Institute of Diabetes and Digestive and Kidney Diseases, 2019). There has also been a 3.1% increase in kidney transplants from 2012 to 2013, resulting in a total of 17,600 transplants nation-wide (National Institute of Diabetes and Digestive and Kidney Diseases, 2019). For patients who undergo successful transplants, their 1-year graft survival rate (i.e., estimate of transplant functioning) is 92% for deceased donor kidneys, and 97% for living donors. Further, there was a significant decrease in the number of hospitalization admissions per year for patients receiving hemodialysis in 2013 from 2005. Within this timeframe, admission rates fell from 2.1 admissions per patient year, to 1.7 admissions per patient year (Institute of Diabetes and Digestive and Kidney Diseases, 2019).

Hemodialysis

As stated by the Institute of Diabetes and Digestive and Kidney Diseases (2019), hemodialysis is a form of replacement treatment that filters waste products from the blood, as the kidneys are unable to function properly. Hemodialysis also controls blood pressure, and maintains the balance of minerals throughout the bloodstream, such as potassium, sodium, and calcium. During hemodialysis treatment, the blood is filtered through a “dialyzer” that occurs outside of the body. A dialyzer is oftentimes referred to as an artificial kidney, as it performs the function of properly working kidneys. Throughout this process, the dialysis machine pumps blood through the filter and then returns the filtered blood back into the body. While this is
occurring, the dialyzer controls how quickly blood flows through the filter and the amount of fluid that is removed from the body (Institute of Diabetes and Digestive and Kidney Diseases, 2019).

**Peritoneal Dialysis**

Peritoneal dialysis differs from hemodialysis, as it uses the lining of the abdomen, referred to as the peritoneum, to filter blood (Institute of Diabetes and Digestive and Kidney Diseases, 2019). Patients receiving peritoneal dialysis have a catheter surgically implanted in the peritoneum prior to initiating treatment. During the process of peritoneal dialysis, a dialysis solution (i.e., water with salt and various additives) flows from an external bag through the catheter inside of the abdomen. Once the dialysis solution has fully entered the catheter, the patient is able to ambulate. Internally, the dialysis solution absorbs waste products and toxins from the bloodstream via the catheter. The dialysis solution and the waste products are then drained from the abdomen back into the empty bag to be discarded (Institute of Diabetes and Digestive and Kidney Diseases, 2019).

**Kidney Transplant**

A kidney transplant is similar to hemodialysis and peritoneal dialysis as it is also a treatment, not a cure (Institute of Diabetes and Digestive and Kidney Diseases, 2019). A properly working transplanted kidney is more effective at filtering waste products and maintaining overall health, compared to dialysis treatments. However, certain medication is critical after the transplantation to ensure that the immune system does not reject the new kidney and treat it as a foreign body. Possible complications after receiving a kidney transplant include bleeding, bladder infections, hernias, or pain or numbness within the inner thighs (Institute of
Diabetes and Digestive and Kidney Diseases, 2019). Transplant rejection is often rare and is less common when the kidney is received from a living donor (Institute of Diabetes and Digestive and Kidney Diseases, 2019).

A growing body of literature has examined the effects of hemodialysis on cognitive functioning (Dixit et al., 2013; Odagiri et al., 2011). More recent literature has investigated executive functioning abilities, particularly in the areas of attention and processing speed in this population (O’Lone et al., 2016). Theories have been postulated that attempt to explain the connection between decreased cognitive functioning and its association with receiving dialysis (Dogukon et al., 2009; Henry et al., 2018). As the number of new cases of ESRD is predicted to increase (CDC, 2017), further investigation is needed to better understand the functional and clinical outcomes of cognitive decline in this population.

**Executive Functioning**

The term executive functioning includes a number of cognitive processes, including planning, attention, self-monitoring, self-regulation, attention, inhibition, and initiation (Goldstein et al., 2014). Decades of research in this area has shown that these cognitive processes are controlled by the prefrontal areas of the frontal lobe (Damasio et al., 2011). In the 1950s, researchers studying psychology and neuroscience grew interested in the specific role of the prefrontal cortex in complex behaviors. Donald Broadbent (1953) first examined the differences between automatic and controlled processes, which soon became referred to as the “filter model”. Further investigation of cognitive processes led to the cognitive control model, which expanded upon Broadbent’s model (Posner et al., 2004). Since the 1970s, 30 additional constructs have been studied under the term “executive functioning”, making the construct
difficult to operationally define throughout the literature (Goldstein et al., 2014). In an attempt to identify the commonalities between each definition, Reynolds and Horton (2006) suggested that executive functions represent the abilities to plan, to “do things”, and to perform complex and adaptive behaviors and actions. To date, researchers have developed their own definitions of executive functioning (McCloskey et al., 2009; Delis, 2004). While each definition is unique, a recent review of the literature suggests that executive functioning is best represented across nine areas of cognition, including attention, flexibility, emotion regulation, initiation, inhibitory control, working memory, planning, organizing, and self-monitoring (Naglieri & Gooldstein, 2013).

The development and conceptualization of executive functioning models have been supported by observations of individuals who have sustained frontal lobe damage (Goldstein et al., 2014). Functional neuroimaging studies have provided evidence for the theory that the prefrontal cortex is responsible for executive functioning abilities (Goldstein et al., 2014). Specifically, research has suggested that two areas of the prefrontal cortex are important for completing tasks that require executive functioning abilities: the anterior cingulate cortex and the dorsolateral prefrontal cortex (Hoshi, 2001). Both of these areas of the prefrontal cortex undergo a period of maturation that lasts into adulthood (Hoshi, 2001). Common models of executive functioning that speak to the function of these brain structures include: the filter model (Broadbent, 1953), cognitive control (Posner & Snyder, 1975), the cross-temporal model (Fuster, 1997), and the integrative model (Miller & Cohen, 2001). Broadbent’s model suggests that a mental “filter” acts as a buffer that actively selects information from the environment that is used for conscious awareness. The mental filter determines the information that is relevant or
irrelevant, and subsequently selects the information that passes through the filter, leaving irrelevant information to be ignored (Broadbent, 1953). In the 1970s, Posner and Snyder (1975) expanded upon the filter model and developed the idea of cognitive control. This model focuses on the examination of higher-level tasks, involving visual searches. Further, cognitive control is also utilized to manage thoughts and emotion (Posner et al., 2004). Overall, cognitive control is responsible for automatic responses and allows an individual to adapt from one situation to the next, depending on the specific goal or task (Posner et al., 2004). Further, in the late 1990s, Fuster (1997) developed the cross-temporal model, which synthesizes the concepts of interference control, planning, and working memory. Fuster proposed that the purpose of executive functioning is to organize behavior. He further explained that “temporal mediation” is the interaction between short-term memory and the attention set (i.e., motor attention; Fuster, 2000). More recent models have built upon the cognitive control model to elucidate executive functioning. Miller and Cohen (2001) developed the integrative model, which focuses on activities that lead to the maintenance of goals. The integrative model is a top-down system, suggesting that sensory and motor processing interact with each other during goal-directed behavior (Miller & Cohen, 2001). This model also suggests that mental maps are created between cognitive input and output, and that different neural pathways compete for the expression of certain behavior (Miller & Cohen, 2001).

In addition to various areas of cognition (e.g., inhibitory control), executive functioning also plays an important role in emotional information processing. Specifically, emotions are mediated by the connection between cortical and subcortical structures (Singh & Young, 2020). An established body of literature has shown that certain subcortical limbic structures are
associated with various areas of emotional functioning. Such structures include the amygdala (i.e., fear and anxiety), ventral striatum (i.e., pleasure and euphoria), insula (i.e., disgust), and the septal region (i.e., aggression) (Kluver & Bucy, 1937). The cortical system, specifically the orbitofrontal and dorsolateral cortices, control the modulation between the limbic system and the prefrontal cortex. This modulatory process is known as “emotion regulation” and is responsible for reactivity and behavior. Disruptions to these neural structures are associated with several symptoms of behavioral dysregulation. For example, disruption to the orbitofrontal region can lead to impulsivity, disinhibition, and irritability. Further, the dorsolateral prefrontal cortex is associated with deficits in judgement, and the anterior cingulate is associated with emotional flattening as well as decreased motivation and initiative (Singh & Young, 2020). Researchers have studied the connection between executive functioning and emotion regulation and have found that the ability to shift one’s attention and engage in cognitive flexibility is imperative for emotion regulation. Further, it has been shown that individuals with impaired executive functioning abilities have difficulty attending to, processing, and utilizing social or emotional cues (Murphy et al., 2012). Clinically, decreased emotional regulation has been associated with poor coping skills, which has been linked to the presence of psychopathology later in life (Izard et al., 2008).

The Impact of Dialysis on Executive Functioning

Recent literature has demonstrated that individuals with CKD, especially individuals with ESRD receiving dialysis treatment, commonly experience cognitive impairment (Dixit et al., 2013; Harciared et al., 2016). Such cognitive impairment is associated with functional and structural brain abnormalities (Chen et al., 2015). Research has suggested that cognitive decline
in patients with ESRD is due to low eGFR, which leads to the accumulation of toxins in the body and subsequently impairs brain functioning (Harciared et al., 2016). Additionally, as health conditions (e.g., cardiovascular disease, diabetes) are frequently comorbid with ESRD, it has been suggested that cognitive impairment may also be associated with these comorbid health conditions (Murray, 2008). Common renal failure treatments, such as hemodialysis, have also been shown to be associated with cognitive impairment, such as dialysis disequilibrium syndrome, cerebral ischemia, or cerebral edema (Tuchman et al., 2013). Dialysis disequilibrium syndrome is not well understood, however, it occurs in patients either during or immediately following their hemodialysis treatment (Zepeda-Orozco & Quigley, 2012). Symptoms of dialysis disequilibrium include intracranial pressure, restlessness, headache, or mental confusion (Zepeda-Orozco & Quigley, 2012). Further, cerebral ischemia involves an insufficient amount of blood flow to the brain, and cerebral edema involves swelling in the brain that is caused by excessive fluid.

It is important to note that as older individuals are prone to experience relatively global neuropsychological dysfunction, research demonstrates that older ESRD patients present with specific impairments in psychomotor speed, attention, and executive functioning (Dixit et al., 2013). Additional research has also addressed the potential confound of the general aging process as the reason for cognitive decline and has provided support for the direct impact of hemodialysis on cognitive impairment. In a review of the literature by O’Lone and colleagues (2016), it was reliably demonstrated that individuals treated with hemodialysis had significantly reduced cognitive abilities compared to the general population in areas of orientation and awareness, perception, memory, verbal functions and language, construction and motor
performance, concept formation and reasoning, and executive functioning. It was noted that hemodialysis patients performed most poorly on tests of orientation and awareness, as well as executive functioning in comparison to a set of normative data on healthy individuals with similar age, sex, ethnicity, and level of education (O’Lone et al., 2016). This body of literature provides support for the impact of hemodialysis on cognitive decline in this population and elucidates the specific cognitive abilities that are impacted.

Additional research has also examined other areas of cognitive functioning. For example, specific memory impairments were recently studied in ESRD patients (Jones et al., 2015). Researchers found that ESRD patients performed poorer when the retrieval of memories required conceptual processing rather than perceptual processing, as temporal brain regions are more susceptible to the effects of renal disease (Jones et al., 2015). Similar research focusing on memory found that recognition abilities are also impaired in ESRD patients (Owolabi et al., 2016). Earlier research has also demonstrated that infantile ESRD is associated with poor neurocognitive outcomes in areas of intellectual and executive functioning, memory, and academic achievement during adolescence (Johnson & Warady, 2012). In terms of initiating attention, research has shown that ESRD patients are less likely to acutely increase their state of arousal in order to allocate attention or engage in action-preparation to assist with attention (Harciared et al., 2016). Specific motor abilities have also been studied in this population, and it has been suggested that ESRD patients have poorer performance in their reaction time and finger tapping abilities (Harciarek et al., 2016; Owolabi et al., 2016). This body of literature suggests that other areas of cognitive decline have been observed in ESRD populations compared to
healthy control groups, including memory abilities, reaction time, cognitive processing, and motor skills.

The Impact of the Interdialytic Interval on Cognitive Functioning

There is a growing body of literature that has examined the impact of the interdialytic interval on cognitive functioning (Henry et al., 2018). Many studies have shown that there are shifts or changes in cognitive functioning that are related to the length of the interdialytic interval (Griva et al., 2003; Costa et al., 2014). For example, some studies have identified significant improvements in cognitive functioning immediately following a single dialysis session (Schneider et al., 2015), whereas other studies have shown significant decline in cognitive functioning hours after a dialysis session (Costa et al., 2014). In response to these inconsistent findings, researchers have suggested that the inherent bias of self-report measures may be responsible (Murray, 2008). However, theories of cognitive impairment have provided further explanations for these discrepant findings (Henry et al., 2018). For example, the toxicity theory of cognitive functioning suggests that the increase in fluid volume that accumulates in between each dialysis treatment leads to shifts in cognitive abilities (Dogukon et al., 2009). This theory also purports that the build-up of waste products and minerals in the bloodstream accumulates during the interdialytic interval leads to mild confusion and cognitive impairment (Williams et al., 2004). Further, osmotic theory of cognitive impairment states that cognitive functioning is influenced by the shift in fluid and solute levels from the pre-to-post dialytic state (Henry et al., 2018). Therefore, cognitive functioning is likely to improve as time passes since receiving dialysis and be poorer during and shortly after dialysis sessions (Henry et al., 2018). As dialysis
disequilibrium may occur directly following a dialysis treatment, this syndrome illustrates the osmotic theory of cognitive functioning in ESRD patients (Zepeda-Orozco & Quigley, 2012).

A growing body of literature has provided support for both the toxicity and osmotic theories. For example, Murray and colleagues (2007) demonstrated that cognitive functioning improved one hour after ESRD patients received hemodialysis treatment. Researchers also found that cognitive abilities in these patients continued to improve 24 hours after receiving hemodialysis (Patel et al., 2016). Conversely, other literature has suggested that the optimal time to communicate with a patient is the day after receiving hemodialysis, as cognitive functioning has declined shortly after receiving hemodialysis in ESRD patients (Schneider et al., 2015). Researchers have further noted that important medical information and instructions are oftentimes provided to patients the day of the dialysis treatment. Such information regarding health status, medication use, and dietary information may be missed, as patients may not be fully attending to the information (Schneider et al., 2015). As previous research has indicated, attention and orientation are the most highly impacted areas of executive functioning (O’Lone et al., 2016), and therefore may be associated with communication challenges between healthcare providers and ESRD patients (Schnieder et al., 2015). This information is critical, as executive functioning abilities are essential in adhering to medical instructions (Schnieder et al., 2015). As recent literature has suggested, ESRD patients are likely to experience deficits in areas of orientation and attention (O’Lone et al., 2016), research should examine the impact of these cognitive deficits on medical adherence and overall health outcomes in this population. Doing so may provide insights into the behavioral aspect of declining health in these patients (e.g., inconsistent medication management).
Overall, recent literature has provided evidence for the decline in executive functioning among patients receiving kidney dialysis (O’Lone et al., 2016). However, limited research has focused on differentiating cognitive decline due to dialysis, as compared to the normal aging process. Therefore, future literature should elucidate the unique impact of dialysis on cognitive functioning, particularly executive functioning abilities in ESRD patients. Further, as theories of cognitive functioning have been postulated to better understand the impact of dialysis treatment on cognitive functioning (Sarnak et al., 2013), research should also aim to support these theories. By testing these theories, research will better understand how increased toxicity and the removal of waste products affects cognitive functioning among kidney dialysis patients. As previous literature has suggested, this information is particularly important for healthcare providers, as cognitive decline may directly impact medical adherence (Schnieder et al., 2015). The current study examined the subjective and objective executive functioning abilities among dialysis patients and postulated that decreased awareness of deficits may be associated with medical adherence, such as medication mismanagement and poor diet, among others. As such, the current study serves as a step toward better understanding how executive functioning abilities relate to these areas.

**Neuropsychological Assessment of Dialysis Patients**

Existing literature has suggested that ESRD patients experience cognitive impairment beyond what is expected of the normal aging process, with significant deficits in executive functioning (O’Lone et al., 2016). Current research, however, has utilized objective testing only between dialysis sessions or shortly after the dialysis treatment (Schnieder et al., 2015; Henry et al., 2018), with a lack of data that assesses patients’ abilities while receiving treatment. As such,
it is unclear as to whether ESRD patients experience greater impairment while receiving dialysis or during the interdialytic period. This is an important question to explore, as dialysis patients interact with and receive medical information from their healthcare providers (e.g., nephrologist, dietician, social worker) while actively receiving dialysis. As current literature has identified this as an area that warrants exploration (Schneider et al., 2015), further research is needed to understand the effectiveness and feasibility of conducting neuropsychological assessments in kidney dialysis clinics. While there is a dearth of feasibility testing within dialysis settings, recent studies have examined the feasibility of implementing various interventions in dialysis clinics. For example, art-based interventions (Carswell et al., 2019), exercise programs (Bennett et al., 2020), and brief neurocognitive screeners (i.e., Montreal Cognitive Assessment (MoCA); Agermann et al., 2017) have all been found to be feasible interventions to administer during dialysis treatments. To date, there is an absence of literature that examines the feasibility of conducting neuropsychological assessments specific to executive functioning during dialysis treatment. Therefore, this area of research is warranted given the clinical implications.
CHAPTER 3: METHOD

Research Design

An exploratory design using de-identified archival data was employed to assess the executive functioning abilities among kidney dialysis patients. These data were taken from a larger study that examined overall behavioral and psychological health in kidney dialysis patients within an urban setting. The first goal of this study was to identify the executive functioning abilities present among kidney dialysis patients and compare these abilities to available normative data. The second goal of this study was to identify the feasibility of conducting neuropsychological assessments within a kidney dialysis clinic.

Participants

A sample of 9 adults between the ages of 51 through 83 years participated in the study. Overall, the sample consisted of 55.6% males (n = 5) and 44.4% females (n = 4), with an average age of 71 ($SD = 10.11$). Participants were recruited from a kidney care dialysis treatment facility in Northwest Philadelphia. The average length of time receiving dialysis was 2.22 years ($SD = 1.30$). Complete demographic information is presented in Table 1 and comorbid medical conditions are presented in Table 2.

Inclusion and Exclusion Criteria

De-identified archival data that were analyzed included (a) participants who were receiving kidney dialysis treatment at the time of data collection, (b) participants who were receiving dialysis for a minimum of three months, and (c) participants who were at least 18 years of age and legally able to provide informed consent prior to data collection. Data would not have been analyzed if the participant(s): (a) was actively experiencing psychosis as reported by their physician in the dialysis center, (b) if their physician or dialysis center staff identified that the
patient had a history of dementia, (c) if they did not or refused to provide informed consent, and (d) if the validity scales on the BRIEF-A were invalid and uninterpretable. However, no persons in the database met the exclusion criteria.

## Measures

### Behavior Rating Inventory of Executive Function - Adult Version (BRIEF-A)

The BRIEF-A is a standardized, self-report measure for adults between the ages of 18 and 90. This measure captures a subjective view of executive function behaviors in the daily environment. It is viewed as an ecological measure of executive functioning and describes how executive functions impact various settings (e.g., home, work). The BRIEF-A is comprised of 75 items which includes three summary scales (i.e., Behavior Regulation, Metacognition, and Global Executive Composite), and nine clinical scales (i.e., Inhibit, Shifting, Emotional Control, Self-Monitoring, Initiation, Working Memory, Planning and Organization, Task Monitoring, and Organization of Materials; Hooper et al., 2015). All items are based on three frequency response options, including “never, sometimes, or often.” The Behavioral Regulation Index (BRI) comprises four clinical scales, including Inhibit, Shift, Emotional Control, and Self-Monitoring. The Metacognition Index (MI) comprises five clinical scales, including Initiate, Working Memory, Plan/Organize, Task Monitor, and Organization of Materials. The Global Executive Composite (GEC) is a summary score of all of the clinical scales. The BRIEF-A also includes three validity scales, including Negativity (i.e., an unusually negative manner in responding), Infrequency (i.e., atypical responding relative to the combined normative and clinical samples), and Inconsistency (i.e., inconsistent responding relative to the combined normative and mixed clinical and healthy adult samples). T scores ($M = 50, SD = 10$) are used to interpret executive functioning abilities on the BRIEF-A. T scores of 65 or higher are considered to be clinically
significant (Roth et al., 2005). The inter-rater reliability ($r = .44 - .68$) was moderate for this measure in the normative sample. Internal consistency was moderate to high for the clinical scales ($\alpha = .73-.90$) and was high for the index scores internal consistency ($\alpha = .93-.96$). Test-retest reliability ($r = .82 - .94$) was high for the clinical scales and index scores (Roth et al., 2005).

**Trail Making Test (Part A)**

The Trail Making Test, Part A (Part A) is a measure of rapid visual scanning, attention and concentration, and cognitive processing speed (Crowe, 1998). In Part A, the participant must trace a trail through a series of 25 numbered circles that are randomly positioned. Scoring is based on how many seconds elapsed for participants to complete the task. Therefore, higher scores denote a greater level of impairment (Reitan, 1958). Part A has high test re-test reliability ($r = 0.76$ to $0.89$) (Wagner et al., 2011), and alternative-form reliability ($r = 0.79$) (de Rosiers & Kavanagh, 1987).

**Trail Making Test (Part B)**

The Trail Making Test, Part B (Part B) is a measure of cognitive flexibility and the ability to rapidly shift cognitive set (Crowe, 1998; Gaudino, Geisler, & Squires, 1995). In Part B, the participant must draw lines that connect 25 encircled numbers and letters in numerical and alphabetical order while alternating between the numbers and letters (i.e., 1 is followed by A, A is followed by 2, 2 is followed by B, B is followed by 3, and so on). The numbers and letters are positioned in a random order to eliminate overlapping lines when connecting the circles. Scoring of Part B involves recording the number of seconds that is required to complete the task. Therefore, higher scores denote a greater level of impairment (Reitan, 1958). Part B has high interrater reliability and alternate forms of reliability ($r = 0.78$ and $0.92$, respectively; Charter et
al., 1987). Part B also does not show evidence for practice effects across a time interval as long as one year, indicating that participants do not “learn” how to take the test (Basso et al., 1999).

**Demographic Questions**

Participants were asked a number of demographic questions regarding their age, ethnicity, sex, and level of education. Participants were also asked the length of time they had been receiving dialysis. Additional items related to comorbid medical conditions were also assessed (e.g., cardiovascular disease, diabetes mellitus).

**Procedure**

De-identified archival data were downloaded and obtained from a REDCap database into SPSSv22. For the purposes of the current study, the archival data were taken from a study approved by the investigator’s institutional review board, which examined overall behavioral and psychological health in kidney dialysis patients (PCOM IRB approval). In the original study, participants were asked to complete an online questionnaire that included demographic and health related items and other measures examining behavioral and psychological health (e.g., depression, sleep). Participants were also asked to complete paper-based neuropsychological tests, including the BRIEF-A and TMT, Parts A and B. All test data were compared to available race-appropriate normative data. The BRIEF-A normative data include a normative sample of over 1,100 adults from ethnic, racial, and educational backgrounds (Roth et al., 2005) and the TMT, Part A and B include normative data of healthy controls of similar age, sex, ethnicity, and level of education (Heaton norms, 2004). In total, there were nine measures on the online questionnaire, one separate online measure, and four paper and pencil assessments. Data collection was completed over the course of two or three sessions, depending on the participants’ availability and length of completion time. The BRIEF-A and the TMT, Parts A and B were
administered at the end of the first session of testing, after participants completed the online questionnaires. Additional de-identified information was collected from patient medical charts, including medication lists, markers of diet (e.g., serum phosphorus levels), and type of dialysis. All patient data were collected prior to the COVID-19 pandemic. For the present study, all data were entered in a single SPSS database and the variables that were collected included all neuropsychological test data (BRIEF-A and TMT, Parts A and B); demographic information including age, ethnicity, length of time receiving dialysis treatment; and comorbid medical conditions. The feasibility of conducting these assessments with a dialysis population was examined via the “Objectives of a Feasibility Study” proposed by Orsmond and Cohn (2015). The objectives that were analyzed included procedures and measures, intervention acceptability, resources and study management, and preliminary evaluation of test data.

**Analyses**

Means and frequencies were used for demographic information, the prevalence of comorbid medical disorders, and length of time receiving dialysis. For the BRIEF-A, T-scores of 65 or greater on the nine clinical scales (i.e., Inhibit, Shifting, Emotional Control, Self-Monitoring, Initiation, Working Memory, Planning and Organization, Task Monitoring, and Organization of Materials) were considered clinically significant in the current sample. For the TMT, Part A and B, the Heaton norms were used (Heaton norms, 2004). This set of normative scores allowed for comparison of age, gender, ethnicity, and level of education in a healthy, non-clinical sample. The current study also investigated whether the sample scores were within one standard deviation of the mean in the normative sample ($M = 50; SD = 10$), which were considered clinically significant.
CHAPTER 4: RESULTS AND DISCUSSION

Seven participants completed the BRIEF-A and nine participants completed both the BRIEF-A and the TMT, Parts A and B. The two participants who did not complete the TMT, Parts A and B did not consent to completing this measure during the time of data collection. The BRIEF-A and TMT, Parts A and B were completed while each participant was receiving dialysis treatment. Demographic variables, including age, sex, ethnicity, level of education, and length of time receiving dialysis are presented in Table 1. The participants also reported on their comorbid medical conditions, which are presented in Table 2. Descriptive statistics for the BRIEF-A are presented in Table 3 and descriptive statistics for the TMT, Parts A and B are presented in Table 4. The feasibility of conducting neuropsychological assessments within a kidney dialysis clinic were examined and described.

Table 1

Demographic Information

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>5 (55.6)</td>
</tr>
<tr>
<td>Female</td>
<td>4 (44.4)</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>6 (66.7)</td>
</tr>
<tr>
<td>White</td>
<td>3 (33.3)</td>
</tr>
<tr>
<td>Length of time Receiving Dialysis</td>
<td></td>
</tr>
<tr>
<td>Less than a year</td>
<td>3 (33.3)</td>
</tr>
<tr>
<td>1-2 years</td>
<td>3 (33.3)</td>
</tr>
<tr>
<td>2-3 years</td>
<td>2 (22.2)</td>
</tr>
<tr>
<td>4-5 years</td>
<td>1 (11.11)</td>
</tr>
<tr>
<td>Level of Education</td>
<td></td>
</tr>
<tr>
<td>High School</td>
<td>3 (33.3)</td>
</tr>
<tr>
<td>Some College</td>
<td>4 (44.4)</td>
</tr>
<tr>
<td>Bachelor’s Degree</td>
<td>1 (11.1)</td>
</tr>
<tr>
<td>Doctoral Degree</td>
<td>1 (11.1)</td>
</tr>
</tbody>
</table>
Ages

<table>
<thead>
<tr>
<th>Gender</th>
<th>M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>66.20 (9.98)</td>
</tr>
<tr>
<td>Females</td>
<td>77.75 (6.40)</td>
</tr>
</tbody>
</table>

Comorbid Medical Conditions

The current sample reported various comorbid health conditions, including Type 2 diabetes mellitus, hypertension, chronic obstructive pulmonary disease, congestive heart failure, back pain, migraines, blood clots, kidney stones, rheumatoid arthritis, asthma, glaucoma and other vision issues, gout, and depression and anxiety. The most common comorbid medical condition was Type 2 diabetes (44%). One third (33%) of the sample also reported a history of blood clots and vision issues and approximately a quarter (22%) of the sample reported currently having hypertension, chronic heart failure, kidney stones, rheumatoid arthritis, gout, and major depression and generalized anxiety. Lastly, 11% of the sample reported having asthma, chronic obstructive pulmonary disease, back pain, migraines, and a history of a cerebrovascular accident (CVA). Two participants did not report a current or past history of any comorbid medical conditions.
Table 2

*Comorbid Medical Conditions*

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 2 Diabetes Mellitus</td>
<td>4 (44%)</td>
</tr>
<tr>
<td>Blood Clots</td>
<td>3 (33%)</td>
</tr>
<tr>
<td>Vision Issues</td>
<td>3 (33%)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>2 (22%)</td>
</tr>
<tr>
<td>Chronic Heart Failure</td>
<td>2 (22%)</td>
</tr>
<tr>
<td>Kidney Stones</td>
<td>2 (22%)</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>2 (22%)</td>
</tr>
<tr>
<td>Major Depression and Generalized Anxiety</td>
<td>2 (22%)</td>
</tr>
<tr>
<td>Gout</td>
<td>2 (22%)</td>
</tr>
<tr>
<td>Chronic Obstructive Pulmonary Disease</td>
<td>1 (11%)</td>
</tr>
<tr>
<td>Asthma</td>
<td>1 (11%)</td>
</tr>
<tr>
<td>Cerebrovascular Accident (CVA)</td>
<td>1 (11%)</td>
</tr>
<tr>
<td>Back Pain</td>
<td>1 (11%)</td>
</tr>
<tr>
<td>Migraine</td>
<td>1 (11%)</td>
</tr>
</tbody>
</table>

Behavior Rating Inventory of Executive Function – Adult Version (BRIEF-A)

The BRIEF-A self-report provides a subjective measure of executive functioning and the ability to regulate one’s environment (Hooper et al., 2015). There are nine clinical scales that capture aspects of executive functioning, including inhibiting (Inhibit), shifting (Shift), self-monitoring (Self-Monitor), initiating (Initiate), planning/organizing (Plan/Organize), task monitoring (Task Monitoring), organizing materials (Organization of Materials), emotional control (Emotional Control), and working memory (Working Memory).

The results from the clinical scales on the BRIEF-A self-report indicated that the sample’s overall average $T$ score for all of the clinical scales were within the sub-clinical range, as average $T$ scores ranged from 45.66 to 53.11. However, one participants scored in the clinical range on the Shift ($T = 69$) and Self Monitor ($T = 66$) scales, which related to emotional-behavioral regulation. These results indicate that 11.1% of the sample viewed themselves as
having difficulty with aspects of their behavioral regulation skills, particularly in regard to
moving from one activity or situation to another, tolerating change, or shifting their attention
(Shift) and monitoring their emotions or behaviors (Self Monitor).

Additional results from the clinical scales showed that four participants scored in the
clinical range in regard to various cognitive abilities, including Plan/Organize ($T = 66$), Task
Monitor ($T = 67$), Organization of Materials ($T = 69$), and Initiate ($T = 71$). These results
indicate that 44% of the sample viewed themselves as having difficulty with higher order
thinking and problem-solving abilities. Specific areas of difficulty were in regard to their ability
to develop goals for future events (Plan/Organize), assess and monitor the progress of their
performance on various tasks (Task Monitor), maintain order and organization of their materials
or belongings (Organization of Materials), and begin an activity or independently generate ideas
or problem-solving strategies (Initiate).

The Global Executive Composite (GEC) index score consisted of nine clinical scales,
including Inhibit, Shift, Emotional Control, Self-Monitoring, Initiate, Working Memory,
Plan/Organize, Task Monitor, and Organization of Materials. The results of the GEC index
score produced a sub-clinical overall average score (GEC, $T = 48$). The sample $T$ scores ranged
from 37 to 59, indicating that none of the participants scored in the clinical range (i.e., $T$ scores
greater than or equal to 65) in their perception of their overall executive functioning abilities.

The Behavioral Regulation Index (BRI) comprises four clinical scales, including Inhibit,
Shift, Emotional Control, and Self-Monitoring. The BRI measures the ability to maintain
appropriate regulatory control of one’s own behavior and emotional responses (Roth et al.,
2005). The results of the BRI index score produced a sub-clinical overall average score (BRI, $T$
$= 47$). The sample $T$ scores ranged from 37 to 67. Subjective issues with inhibiting emotional
responses, modulating emotions, or monitoring social behavior was only identified for one participant, as measured by the BRI \((T = 67)\), indicating that the remaining eight participants did not view these aspects of executive functioning as problematic.

The Metacognition Index (MI) comprises five clinical scales, including Initiate, Working Memory, Plan/Organize, Task Monitor, and Organization of Materials. The MI reflects the ability to initiate activity and general problem-solving ideas, sustain working memory, monitor success and failure in problem-solving, and organize one’s materials and environment (Roth et al., 2005). The results of the MI index score produced a sub-clinical overall average score (MI, \(T = 49\)). The sample \(T\) scores ranged from 38 to 63. These results indicate that overall, the sample did not view themselves as having difficulty with these areas of executive functioning.

**Table 3**

*BRIEF-A Self-Report Scores*

<table>
<thead>
<tr>
<th>Clinical Scales</th>
<th>(T) Scores</th>
<th>Range of Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>Minimum – Maximum</td>
</tr>
<tr>
<td>Inhibit</td>
<td>51.22 (7.87)</td>
<td>41 – 63</td>
</tr>
<tr>
<td>Shift</td>
<td>47.00 (9.05)</td>
<td>40 – 69</td>
</tr>
<tr>
<td>Emotional Control</td>
<td>46.77 (7.45)</td>
<td>40 – 59</td>
</tr>
<tr>
<td>Self-Monitoring</td>
<td>47.22 (11.00)</td>
<td>38 – 66</td>
</tr>
<tr>
<td>Initiate</td>
<td>53.11 (11.65)</td>
<td>39 – 71</td>
</tr>
<tr>
<td>Working Memory</td>
<td>47.55 (6.44)</td>
<td>40 – 62</td>
</tr>
<tr>
<td>Plan/Organize</td>
<td>50.44 (8.51)</td>
<td>40 – 66</td>
</tr>
<tr>
<td>Task Monitor</td>
<td>45.66 (9.76)</td>
<td>38 – 67</td>
</tr>
<tr>
<td>Organization of Materials</td>
<td>48.77 (8.71)</td>
<td>40 – 69</td>
</tr>
</tbody>
</table>

Composite Scores

<table>
<thead>
<tr>
<th></th>
<th>(T) Scores</th>
<th>Range of Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Executive Composite (GEC)</td>
<td>48.22 (8.07)</td>
<td>37 – 59</td>
</tr>
<tr>
<td>Behavior Regulation Index (BRI)</td>
<td>47.33 (9.12)</td>
<td>37 – 67</td>
</tr>
<tr>
<td>Metacognition Index (MI)</td>
<td>49.11 (8.43)</td>
<td>38 – 63</td>
</tr>
</tbody>
</table>
Trail Making Test, Part A and B

The TMT, Part A and B provides an objective measure of executive control. Part A measures rapid visual scanning, attention and concentration, and cognitive processing speed. Part B measures cognitive flexibility and the ability to rapidly shift cognitive set. The TMT, Parts A and B has a mean of 50 and a standard deviation of 10 (Reitan, 1958). The results of the TMT, Part A produced an overall score in the Below Average range ($T = 44.85$), with scores ranging from the Mildly impaired range ($T = 38$) to the Average range ($T = 51$), indicating that six out of seven participants demonstrated intact abilities in their rapid visual scanning, attention and concentration, and cognitive processing speed abilities, in comparison to matched controls with similar sex, age, ethnicity, and level of education (Heaton norms, 2004). The results from the TMT, Part B produced an overall score in the Below Average range ($T = 43.57$), with scores ranging from the Moderately impaired range ($T = 28$) to the Above Average range ($T = 60$). Further, five out of seven participants demonstrated intact abilities in their cognitive flexibility and ability to rapidly shift cognitive set, in comparison to matched controls with similar sex, age, ethnicity, and level of education (Heaton norms, 2004).

Table 4

<table>
<thead>
<tr>
<th>Test</th>
<th>Average $T$ Score</th>
<th>Range of Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part A</td>
<td>44.85</td>
<td>38 – 50</td>
</tr>
<tr>
<td>Part B</td>
<td>43.57</td>
<td>28 – 60</td>
</tr>
</tbody>
</table>

Participant $T$ Scores

<table>
<thead>
<tr>
<th>Part A</th>
<th>Qualitative Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>Average</td>
</tr>
<tr>
<td>43</td>
<td>Below Average</td>
</tr>
<tr>
<td>40</td>
<td>Below Average</td>
</tr>
</tbody>
</table>
Mildly Impaired            38
Average                   50
Average                   47
Average                   45

Part B Qualitative Description

Mild - Moderate            32
Below Average              44
Average                   49
Moderate                  28
Above Average             60
Average                   45
Average                   47

**Case Examples**

**Participant “David”**

David is a 73-year-old African American male with 13 years of education. He has been receiving dialysis for the past two to three years with no known medical comorbidities. On the BRIEF-A, his BRI was elevated \( T = 67 \) with two of the clinical scales in the clinical range (Shift, \( T = 69 \); Self-Monitor, \( T = 66 \)). These results suggest that David views himself as having difficulty with abilities that are associated with behavioral regulation. Specific areas of impairment that he identified involved his ability to move from one activity or situation to another, tolerate change, or easily switch his attention (Shift). Other areas of impairment that he identified included difficulty with monitoring the impact of his own behavior in social settings (Self Monitor). Conversely, his scores on the TMT, Part A and B were in the Average range (Part A = 47; Part B = 45). Taken together, these results suggest that there is a discrepancy in David’s subjective and objective executive functioning abilities. Specifically, David’s objective executive functioning abilities are intact, whereas he views himself as having some emotional-behavioral dysregulation. While his BRIEF-A scores show subjective difficulty with behavioral
regulation abilities, rather than cognitive impairments, the clinical implications of his case warrant exploration.

Given David’s presentation, it can be hypothesized that he may experience possible dependency on others and poor self-esteem, given his perceived lack of behavioral regulation and intact executive functioning abilities. However, his level of dependency was not specifically measured in the current study. However, a growing body of literature has suggested that older adults (i.e., 65+ years old) receiving hemodialysis are dependent on other individuals to accomplish instrumental activities of daily living (IADLs; Cook & Jassal, 2008). Common activities that require dependency among these individuals include medication management, meal preparation, and general housework, among others. While dependency may be medically required for some older adults who cannot independently complete IADLs, it is important to consider other variables that may be associated with dependency. In considering David’s case, possible low self-esteem may relate to dependency on others, especially given his intact objective executive functioning abilities. Despite this finding, further evaluation is needed to understand the discrepancy between his perceived and actual functioning. Additional factors should also be considered, including external sources that may contribute to low self-esteem, such as negative feedback from family members. Of note, research has shown that self-esteem is significantly lower in individuals receiving hemodialysis compared to the general population (Rezaei & Salehi, 2016). These patients are also more likely to engage in emotion-oriented coping styles, which involves managing the emotions associated with a stressful situation rather than addressing the situation itself (Rezaei & Salehi, 2016; Lazarus, 1999). David’s elevated BRI composite score suggests that he is likely to engage in emotion-oriented coping, which may lead him to be dependent on others. While additional information is needed to more accurately
capture the implications of David’s case, recent literature examining the increased dependency and decreased self-esteem in this population provides clarity on the discrepancy between his subjective and objective executive functioning abilities. An additional hypothesis that may further explain David’s emotional dysregulation involves possible organic changes or damage to sub-cortical structures of the limbic system (e.g., amygdala). As a result, this would not contribute to impairments in executive functioning and would rather be associated with emotional-behavioral dysregulation concerns, as observed in David’s profile.

**Participant “John”**

John is a 74-year-old Caucasian male with 16 years of education. He has been receiving hemodialysis for the past 1-2 years and his reported medical comorbidities include congestive heart failure and Type 2 diabetes. His scores on the BRIEF-A composite scores and clinical scales were all within the sub-clinical range ($T < 65$). However, his performance on the TMT, Part A was in the Mildly impaired range ($T = 38$) and his performance on the TMT, Part B was in the Moderately impaired range ($T = 28$). These results suggest that John lacks a degree of awareness or insight regarding his executive functioning abilities. Further, his clinical profile is supported by a growing body of literature that suggests that individuals receiving hemodialysis commonly experience deficits in orientation and awareness (O’Lone et al., 2016). This body of literature has also shown that deficits in orientation and awareness are greater among hemodialysis patients compared to the general population (O’Lone et al., 2016). In addition to the impact of hemodialysis on aspects of cognitive functioning, John’s medical comorbidities may also be negatively impacting both his impaired executive functioning abilities and level of awareness. Established literature has shown that individuals diagnosed with Type 2 diabetes demonstrate impaired abilities in various aspects of cognitive functioning, with two major areas
being executive functioning and awareness (Takeuchi et al., 2011). Given this information, a template match associated with Type 2 diabetes and hemodialysis indicated a strong match with John’s clinical profile.

**Feasibility of Administering Neuropsychological Assessments**

Several variables were considered when assessing the feasibility of administering neuropsychological assessments within a dialysis clinic setting. Ormond and Cohn (2015) outlined objectives that were designed to better understand the barriers to the success of feasibility studies. The objectives that were utilized in the current study included (a) evaluation and refinement of data collection procedures and outcome measures, (b) evaluation of acceptability and suitability of intervention and study procedures, (c) evaluation of resources and ability to manage and implement the study and intervention, and (d) preliminary evaluation of participant responses to intervention.

**Evaluation and Refinement of Data Collection Procedures and Outcome Measures**

This first objective examined the appropriateness of the data collection procedures and outcome measures (Orsomond & Cohn, 2015). Specific areas that were analyzed included the participant’s ability to complete the measures (e.g., comprehension), whether the data were complete and interpretable, appropriateness of the amount of data collection (i.e., completion time), and whether the measures were appropriate for a dialysis population. During the data collection process, seven participants completed the BRIEF-A and the TMT, Part A and B and two additional participants completed only the BRIEF-A. During the administration of the BRIEF-A, the evaluator read the items aloud to participants as a way to reduce the amount of writing required by participants, since one arm was compromised due to the access port for hemodialysis. The participants did not express any difficulty with understanding or
comprehending the 75 self-report items and there were no missing data. Previous research has not specifically examined the feasibility of self-report measures with dialysis patients while actively receiving dialysis. However, previous studies have shown the use of self-report measures across various constructs, including frailty and chronic pain (Chao et al., 2015), diet (Vlaminick et al., 2001), and depression (Craven et al., 1989). Despite this existing body of literature, there is no current research or indication from the current study that suggests that the BRIEF-A is an inappropriate measure to use with this population.

Upon completion of the BRIEF-A, participants completed the TMT, Parts A and B. One modification was made to the standardized administration, which involved participants using a clipboard instead of a tabletop surface. None of the participants expressed confusion or indicated that they did not understand the test instructions. Further, all participants completed the assessment in full without any errors. The completed and interpretable data were compared to a normative sample of healthy age, gender, ethnicity, and level of education-matched controls (Heaton norms, 2004).

The appropriateness of the amount of data collection (i.e., time completion) was also analyzed. The current study utilized a single self-report measure and a single objective measure to assess executive functioning abilities. For the BRIEF-A, the suggested time completion is 10 to 15 minutes for individuals who complete the measure independently (Roth et al., 2005). While the current study did not measure the number of minutes each participant required, the average estimated completion time was within 10 to 15 minutes. For the TMT, Parts A and B, standardized administration allows for discontinuation of the test if the participant exceeds 5 minutes for Part A and B. The results of the TMT, Part A completion time ranged from 32 seconds to 60 seconds and the TMT, Part B completion time ranged from 70 seconds to 212
seconds. As such, the longest estimated completion time for both the BRIEF-A and TMT, Parts A and B in the current sample was 19 minutes and 32 seconds (i.e., the highest score on the TMT, Parts A and B in minutes; 15 minutes for the BRIEF-A) and the shortest estimated completion time was 14 minutes and 42 seconds (i.e., the lowest score on the TMT, Parts A and B in minutes; 10 minutes for the BRIEF-A).

In addition to the appropriateness of the amount of data collection, the appropriateness of the use of these measures in a dialysis population was also considered. Primarily, face validity suggested that the use of the BRIEF-A and the TMT, Part A and B is appropriate and feasible within this population, especially considering the lack of confusion with administration instructions, lack of errors and missing data, and short completion times. Further, a meta-analysis recently showed that, across 22 studies examining cognitive functioning abilities in this population, the TMT, Part A was the most frequently administered test (O’Lone et al., 2016). While it was not clear whether or not the participants in these studies completed testing while actively receiving dialysis, the results of the current study suggest that administration of the TMT, Parts A and B during dialysis treatments is feasible and appropriate for this population.

**Evaluation of Acceptability and Suitability of Intervention and Study Procedures**

The second objective examined whether the study procedures were suitable for and acceptable to participants (Orsomond & Cohn, 2015). Specific areas that were analyzed included retention and intervention attendance, participant engagement, and safety and unexpected adverse events. Given the short completion time for testing, multi-session testing was not required, indicating that retention and intervention attendance were not barriers in the current study. Notably, a unique characteristic of testing within a dialysis clinic involves the increased reliability of the patients being present for their treatment. As such, the patients’
dialysis schedule can also serve as a testing schedule, if warranted, depending on the amount of testing to be completed. Further, conducting testing in this way does not require patients to return to the clinic on a non-treatment day. Given the increased fatigue among dialysis patients (Horigan et al., 2012), this method is particularly efficient for both the examiner and the patients. Participants’ levels of engagement during data collection were also analyzed. Observationally, participants in the current sample expressed enthusiasm and engagement while interacting with the examiner. Several participants stated that the dialysis process decreased their social interaction which subsequently led to decreased mental health (e.g., major depression). These personal accounts have been reflected in an existing body of literature focusing on the effects of dialysis on overall mental health (Weisbord, 2016; Ma & Li, 2016). Therefore, this approach provides social interaction for patients and further provides justification for the feasibility of conducting neuropsychological assessments in a dialysis clinic setting.

Conversely, adverse events during data collection were considered and analyzed. The most significant event that occurred in the current study involved increased noise in the dialysis clinic. Sources of noise involved consistent dialyzer monitor tones and nurses or other patients speaking loudly. Despite this disruption, the participants did not express any difficulty hearing or understanding the examiner. Other factors that were considered involved the patients’ level of fatigue, especially if testing occurred toward the middle or end of the dialysis treatment. Potential adverse events that may arise, but were not observed in the current study, include the patient requiring medical attention (i.e., due to complications with their dialysis) or experiencing chronic fatigue.
Evaluation of Resources and Ability to Manage and Implement the Study

The third objective examined whether the research team had the resources and ability to manage the study (Orsomond & Cohn, 2015). Specific areas that were analyzed included physical space, administrative capacity, expertise and skill, equipment, budgetary considerations, and ethical considerations. Since the data were collected during dialysis treatments, the seating logistics for the examiner was initially considered. Consultation with the nephrologist, social worker, and nurses resulted in the examiner using a backless swivel chair next to the patient in the clinic for data collection. Given the layout of the clinic, there was enough space in between each dialysis chair for up to two examiners to sit next to a patient. Regarding administrative capacity and study procedures, all completed hard-copy protocols were kept in a locked filing cabinet that was located in the same building as the dialysis clinic. All demographic variables (e.g., age, sex, level of education) were collected via an encrypted and HIPAA compliant database (i.e., REDCap) and downloaded into a password protected SPSSv22. Each participant was assigned a unique study identification number and all data were deidentified.

The level of training of the examiners was also considered during data collection. All examiners were doctoral students in clinical psychology who passed the required psychological assessment courses within the program’s curriculum. The examiners were also trained in the standardized administration of the TMT, Parts A and B by a fourth-year doctoral candidate. The required equipment and materials that were needed for data collection were also considered. For both the BRIEF-A and the TMT, Parts A and B, a clipboard was required as the participants completed the assessments in their dialysis chair. Additional materials for the TMT, Parts A and B included a stopwatch for completion time and a pencil without an eraser.
Regarding pricing considerations, the TMT, Parts A and B is not trademarked and is in the public domain (i.e., can be accessed online at no cost). However, the BRIEF-A requires at least a Level B qualification for purchase from Psychological Assessment Resources (PAR, Inc). Level B qualification requires:

- A degree from an accredited 4-year college or university in psychology, counseling, speech-language pathology, or a closely related field plus satisfactory completion of coursework in test interpretation, psychometrics and measurement theory, educational statistics, or a closely related area; or license or certification from an agency that requires appropriate training and experience in the ethical and competent use of psychological tests. (Psychological Assessment Resources, 2021)

Purchasing options for the BRIEF-A include an Introductory Kit (i.e., BRIEF-A professional manual, 25 self-report and informant report forms and 25 self-report and informant report scoring summary/profile forms: $384.00), Professional Manual or e-Manual ($113.00), Self and informant-report forms, 25-count ($91.00 each), and Self and informant-report scoring summary/profile forms ($62.00, each).

Ethical considerations were also identified during the implementation of the study. The most significant risk to the participant’s confidentiality involved conducting all aspects of the study in the dialysis clinic. This represents an ethical consideration, as medical staff and other patients are in close proximity and may have overheard a participant’s response (e.g., when answering BRIEF-A questions). To increase participants’ comfort level, they were given the option to complete the measure independently. However, all study participants requested that the examiner read the questions aloud to them. They also stated that this method provided increased social interaction while attending their dialysis treatment. Fortunately, breaches of
confidentiality did not occur during the implementation of the current study. An additional ethical consideration involves the possible risk of decreased self-esteem or view of their abilities when performing the TMT, Parts A and B and the BRIEF-A. While this was not observed with the current sample, the examiners are trained in evidenced-based interventions. As such, clinical skills could have been utilized during data collection, if warranted.

**Preliminary Evaluation of Participant Responses to Intervention**

The fourth objective examined whether the intervention showed promise of being successful with the intended population (Orsmond & Cohn, 2015). Specific areas that were analyzed included whether the preliminary data suggested that the intervention was likely to be successful and whether the participants or relevant others provided qualitative feedback that may have indicated that the intervention would be successful. The results of the preliminary testing revealed that, on average, the current sample scored within a sub-clinical range on the BRIEF-A (i.e., T scores of 65 or below). Results also showed that on average, participants scored on the high end of the Below Average range on the TMT, Parts A and B (Part A, \( T \) score = 44.85; Part B, \( T \) score = 43.57; Heaton norms, 2004). While confidence intervals are not provided in the normative scores for the TMT, Parts A and B, these results indicate that the study participants were functioning at least within a non-impaired range. These results further suggest that possible extraneous variables (e.g., dialyzer tones, nurses or other patients speaking) did not negatively impact participant performance on these measures, given the lack of impaired scores. As such, this indicates that the administration of the BRIEF-A and the TMT, Parts A and B showed promise of being successful within a dialysis clinic setting. Lastly, the qualitative feedback that was provided by participants further supported this conclusion. While a qualitative analysis was not utilized in the current study, the participants commented positively on their performance
during data collection (e.g., “I did pretty good with that!” in reference to the TMT) and indicated that they appreciated the social interaction.

**Interpretation and Implications**

The current study presents the findings from an exploratory project aimed at assessing executive functioning abilities among dialysis patients and the feasibility of conducting neuropsychological assessments within a dialysis clinic. The first objective involved understanding how the sample’s executive functioning abilities compared to available normative data of healthy individuals with similar, age, sex, ethnicity, and level of education. The second objective involved identifying and analyzing variables associated with the feasibility of conducting the BRIEF-A and TMT, Parts A and B while participants were receiving dialysis. Exploratory analyses demonstrated that these measures are feasible and useful to use within a dialysis clinic setting. Preliminary quantitative results indicated that, on average, the sample did not have elevated scores on the BRIEF-A composite scores or clinical scales. This suggests that the sample as a whole did not view themselves as having difficulty with various thinking skills associated with executive functioning. However, on an individual level of analysis, the data revealed that two out of the nine participants identified difficulty with aspects of their behavioral regulation skills, particularly in regard to moving from one activity or situation to another, tolerating change, or shifting their attention and monitoring their emotions or behaviors. Further, four participants identified difficulty with aspects of cognitive abilities, involving planning, organizing, monitoring and organizing, and initiating tasks. The objective data from the TMT, Parts A and B indicated that, on average, the sample performed in the Below Average range. These results indicate that, overall, the participants did not demonstrate impaired executive functioning abilities. Again, on an individual level of analysis, one out of seven participants
demonstrated an impaired ability in visual scanning, attention and concentration, and cognitive processing speed (Part A) and in the ability to shift cognitive set (Part B). Further, one out of the seven participants demonstrated impaired abilities only in shifting cognitive set (Part B).

In reviewing the sample’s performance on the BRIEF-A and the TMT, Parts A and B, two participants’ profiles were clinically significant and warranted a more in-depth analysis. The first participant, David, was a 73-year-old African American male with 13 years of education and no medical comorbidities. He presented with elevated perceived difficulty with aspects of behavioral regulation, particularly in his ability to move from one activity or situation to another, tolerate change, or easily switch his attention, as well as in his ability to monitor his performance on various tasks. Interestingly, his performance on the TMT, Parts A and B was in the Average range, indicating that he did not demonstrate objective impairment in executive functioning. It is important to note that David’s perception of his executive functioning difficulties is associated with behavioral dysregulation, rather than cognitive impairment. His profile supports the possibility that he may be experiencing a sense of dependency on others and poor self-esteem, especially given his perceived lack of behavioral regulation. These results further suggest the need for behavioral health services in a dialysis clinic setting. Recent literature has shown that integrated behavioral health for end-stage renal disease patients is associated with better clinical outcomes, especially for those patients with comorbid medical issues (e.g., diabetes, congestive heart failure; Datta & Ogbeide, 2019). Furthermore, mental health professionals can also provide evidence-based interventions to reduce maladaptive cognitions and behaviors, such as low self-esteem and dependency on others, which can lead to altered self-perception, as observed in David’s case.
The second participant, John, also presented with a clinically significant profile. He is a 74-year-old Caucasian male with 16 years of education. His medical comorbidities include congestive heart failure and Type 2 diabetes. He presented with sub-clinical scores on the BRIEF-A, indicating that he does not view himself as having difficulty with various thinking skills associated with executive functioning. Interestingly, his performance on the TMT, Part A was Mildly impaired and his performance on Part B was Moderately impaired. John’s clinical profile indicates that he lacks a degree of awareness regarding his executive functioning abilities. This finding aligns with a growing body of literature that shows that orientation and awareness are significantly, negatively impacted among dialysis populations compared to healthy adults (O’Lone et al., 2016). John’s clinical profile suggests the need for the presence of mental health professionals in dialysis clinics and routine neurocognitive testing for dialysis patients given the significant implications of decreased executive functioning abilities and impairment in orientation and awareness. These implications may include medication non-adherence, poor diet, missed dialysis appointments, and noncompliance with other medical instructions or recommendations (Schnieder et al., 2015). As such, mental health providers can implement effective interventions to promote patients’ awareness of maladaptive behaviors, including activity scheduling, visual cues, and alarm clocks which may ultimately promote better health outcomes (Farragher & Jassal, 201

**Strengths**

There are several strengths of the current study noted. First, and most importantly, the study provided further insight into the executive functioning abilities among patients receiving kidney dialysis. This study also provided specific information regarding two participants in the current sample that presented with clinically relevant profiles. These two participants were in
contrast to one another yet provided an anecdotal view into their overall unique levels of functioning. To that end, the information that was gleaned from their specific cases allowed for clinical recommendations, such as the need for mental health providers within a dialysis clinic setting. Another significant strength of the current study involved providing clinically relevant information for physicians and psychologists treating this population. Specifically, one piece of datum from the sample aligned with existing literature showing that dialysis patients experience significant impairment in orientation and awareness (O’Lone et al., 2016). The current study also speaks to the importance of mental health treatment among this population, and how mental health providers can assess for cognitive decline among this population. Further, this information may help to inform treatment, and may also assist in problem-solving during problematic situations (e.g., missed appointments, decreased medication adherence). Additional strengths involved the use of subjective and objective measures of executive functioning, as well as available normative data based on age, sex, ethnicity, and level of education. Lastly, the current study analyzed various factors that support the feasibility of conducting neuropsychological assessments within a dialysis clinic setting.

Limitations

The current study included several limitations. The most significant limitation was that data collection began prior to the COVID-19 pandemic and was ultimately interrupted as a result. As such, the current study involved a limited sample size of individuals within a single urban area. It is also important to consider that, given this limited sample within a single geographic area, the subjective views of executive functioning may have reflected various challenges that are relative to the environment of the participant. Given the limited sample size, an exploratory design was utilized, and no statistical analyses were conducted. Therefore,
specific conclusions regarding the relationships between certain groups (e.g., TMT, Parts A and B scores and BRIEF-A scores) were not possible, and the direct impact of kidney dialysis on executive functioning abilities was not studied. Additionally, the current study did not utilize the informant-report version of the BRIEF-A. Including this measure would have provided a multifaceted view of participants’ executive functioning abilities and would have contributed to the overall richness of the data. Additionally, since the items on the BRIEF-A self-report were read aloud to the participants, the possibility of response bias exists within the data. Other limitations involved possible extraneous variables, including increased noise within the dialysis clinic that may have negatively impacted the sample’s performance on the TMT, Parts A and B, despite overall intact scores. While fatigue did not appear to negatively impact the participants’ performances on the measures, it was not specifically measured. Therefore, it is unclear if fatigue negatively impacted the participants’ performances on testing. Further, a quantitative measure was not used to more specifically study the feasibility of conducting neuropsychological assessments in this setting.

**Future Directions**

Future research should aim to examine the direct impact of kidney dialysis on executive functioning. As the current study was exploratory in nature, inferences from causal relationships were not possible. Therefore, additional research should employ an experimental design that examines the differences between kidney dialysis patients and a healthy control group. Specific areas to consider involve comparing objective abilities among various demographic variables (e.g., sex, age groups, level of education). Other experimental designs should examine the length of time receiving dialysis on executive functioning abilities, as well as the severity level of renal disease on executive functioning abilities. An additional variable that should be quantitatively
measured involves adherence to medical instructions or recommendations and how it relates to executive functioning abilities, such as medication adherence, dialysis treatment attendance, and diet, among others. Further, research should also incorporate various measures of executive functioning to gain a more reliable and robust understanding of these abilities among this population. Similarly, future research should also consider other areas of cognitive functioning among this population, such as immediate and delayed visual and auditory memory, perceptual reasoning, and processing speed. Regarding the clinical use of neuropsychological assessments within this setting, additional recommendations have been derived from the current study. Such recommendations involve providing psychoeducation to the medical staff in the dialysis clinic. This would allow for a multi-disciplinary, team-based approach and will ultimately educate the medical staff about the importance of assessing cognitive functioning among this population. Further, the use of verbally administered neuropsychological assessments, rather than paper-and-pencil-based assessments, is also highly recommended. As dialysis patients may experience limited mobility with the use of their upper extremities due to their access port, this is a factor that clinicians should be aware of and sensitive towards. To that end, several neuropsychological assessments could be considered, including the California Verbal Learning Test, 2nd edition (CVLT-II), Mini Mental Status Exam (MMSE), Controlled Oral Word Association Test (COWAT), and Stroop Test, among others. These measures will also allow for the assessment of a wide range of cognitive abilities that should be explored within this population. Lastly, while data were collected prior to the COVID-19 pandemic, future administration of neuropsychological assessments will require the use of personal protective equipment (PPE). Common PPE includes a face mask, surgical gloves, and a face shield. For administration of the TMT, Parts A and B specifically, there are limitations with the use of PPE that may impact
standardized administration. Such limitations include visual obstructions if the face mask develops condensation and slowed writing speed while wearing surgical gloves.

**Conclusion**

The exploratory nature of the current study provides insight into the subjective and objective executive functioning abilities among a small sample of dialysis patients within Northwest Philadelphia. Despite the lack of an exploratory design, the current study examined two participants in particular who presented with clinically noteworthy profiles. Clinical recommendations were drawn from the two cases, involving the need for routine psychological testing and behavioral health services within this setting. Additionally, the current study examined the feasibility and usefulness of conducting neuropsychological assessments within a dialysis clinic setting. Various areas were addressed, including data collection procedures and outcome measures, the acceptability and suitability of intervention and study procedures, evaluation of resources and ability to manage and implement the study, and preliminary evaluation of participant responses and data. This in-depth analysis suggested that the administration of the BRIEF-A and the TMT, Parts A and B are, in fact, feasible to use within a dialysis clinic setting. The implications of this study, particularly involving the feasibility and usefulness of neuropsychological testing, are clinically relevant for healthcare professionals working with this population. Such implications involve being able to identify potential deficits in executive functioning abilities and how these deficits may negatively impact aspects of medical adherence, such as medication management. Lastly, the current study also provides practical recommendations to help guide future clinical uses of neuropsychological assessments within this setting.
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