1988

The Role of Dietary Compliance in Survival of Hemodialysis Patients.

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The role of dietary compliance in survival of hemodialysis patients

Ruggiero, Laurie, Ph.D.
The Louisiana State University and Agricultural and Mechanical Col., 1988

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The Role of Dietary Compliance in Survival of Hemodialysis Patients

A Dissertation

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Doctor of Philosophy in The Department of Psychology

by Laurie Ruggiero
B.A., Pennsylvania State University, 1981
M.A., Louisiana State University, 1985
May 1988
ACKNOWLEDGEMENTS

I would like to take this opportunity to acknowledge and thank a number of individuals who were very important in my life during the course of completing my dissertation.

First, I would like to thank my committee members who guided my efforts and fostered my professional development during this endeavor. These individuals included Phil Brantley, Ph.D., my major professor, Steve Elliott, Ph.D., Mary Lou Kelley, Ph.D., Arthur Riopelle, Ph.D., Bill Waters, Ph.D., and Kia Bentley, Ph.D., my outside committee member.

Next, I would like to thank my two closest friends during this endeavor, Mike Carey and Barrie Guise, who provided me with seemingly unlimited support and understanding throughout this "often" difficult process.

And, as always, I would like to thank my family for their continued caring and support even though it was often difficult for them to understand the process of completing my dissertation or 'the paper', as it became fondly called. And yes, mom, dad, Mare, Angel, Cesira, and Mike, I am a doctor.
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Abstract

The goal of the current study was to gain knowledge of the role that dietary compliance plays in the survival of end-stage renal failure patients receiving chronic in-center hemodialysis. As a result of this type of research, health care professionals may better understand the individual and collective influence that various aspects of dietary compliance have on survival. This knowledge would also be helpful in the identification and intervention of dietary noncompliance in hemodialysis patients.

The present study investigated the relation of three commonly employed physiological parameters of dietary compliance to survival on hemodialysis and how well these dietary variables independently and relative to important demographic/medical history variables, predict survival in these patients.

Subjects in this study included 110 hemodialysis patients from two hemodialysis centers in a large southern city. Predictor variables included three dietary variables, serum potassium, interdialysis weight gain, blood urea nitrogen; three demographic variables, age, sex, race; and three medical history variables, age at onset of chronic dialysis, years on dialysis, and number of concurrent diagnoses. The criterion variable was group, survivors or deceased, for the discriminant vi
function analyses conducted or length of survival for the regression analyses.

Correlational procedures, discriminant function analyses, and multiple regression analyses were employed to investigate the role that dietary compliance plays in the survival of hemodialysis patients. In general, the results suggest that dietary compliance variables, as measured in this study, play a minimal role in the survival of end-stage renal failure patients. The three dietary variables studied offered little to the prediction of survival after the effects of important demographic/medical history variables were considered. The results also garnered support for the use of multiple measures of dietary variables instead of single data points when conducting this type of research. In summary, the current study failed to provide support for the validity of dietary compliance variables as good predictors of survival in hemodialysis patients. The current findings should be interpreted conservatively, however, pending further research on the reliability and validity of the employed measures of dietary compliance.
THE ROLE OF DIETARY COMPLIANCE IN SURVIVAL
OF HEMODIALYSIS PATIENTS

End-stage renal disease (ESRD) is a devastating problem, both at the personal and national levels. In the United States, approximately 1 in 10,000 persons develop ESRD each year. This disorder creates a great expense for the national economy because almost all ESRD patients are covered by the Renal Medicare program, which assisted approximately 80,000 patients in 1983 (Luke, 1985). For these 80,000 patients, the situation is very bleak at the personal level. A small number of fortunate patients, approximately 3700, receive kidney transplants each year. The majority of ESRD patients do not receive transplants or are transplant failures and must depend on chronic dialysis for survival (Luke, 1985).

In addition to dialysis, the medical management of this disorder involves strict dietary recommendations. Although research has indicated that dietary manipulation may slow the progression of chronic renal failure (e.g., Acchiardo, Moore, & Cockrell, 1984; Barsutti, Giannoni, Morelli, Lazzeri, Vlamis, Baldi, & Giovannetti, 1984), the importance of dietary recommendations in ESRD is not clear.

The introduction to this paper highlights the treatment and medical complications of chronic renal failure, with a special emphasis on hemodialysis and
dietary modifications. The measurement of compliance in health care is also reviewed with special coverage of the measurement of compliance in dialysis patients. Previous research on the role of dietary compliance in survival of dialysis patients is discussed and the current study is presented which investigates the role of dietary compliance in survival of hemodialysis patients.

Chronic Renal Failure

The kidneys play a significant role in the healthy functioning of the body. The primary functions of the normal kidneys include: (a) regulation of the body fluid level, (b) balancing the chemicals, i.e., electrolytes, in the body, (c) removal of waste products from the body through urinary excretion, and (d) secretion of hormones involved in the regulation of blood pressure and production of red blood cells, and (e) metabolism of calcium, phosphorus, and vitamin D (e.g., Klahr, 1985). The gradual malfunctioning of the kidneys is called chronic renal failure (CRF) and is defined as a progressive and irreversible decrease in the glomerular filtration rate (GFR). The GFR is a measure of the kidneys' performance and generally involves determining how much of a substance (e.g., urea) is cleared from the plasma as it passes through the kidneys. Chronic renal failure can be divided into three categories for descriptive purposes including: (a) early CRF with a GFR
of 10-30 ml/min, (b) late CRF with a GFR of 5-10 ml/min, and (c) terminal CRF with a GFR below 5 ml/min (Kerr, 1979).

**Uremic syndrome.** The clinical manifestation of CRF is characterized by the "uremic syndrome." Uremia results from the retention of toxins in the body, i.e., autointoxication and may result in impairment of functioning of all systems of the body. Although the manifestation of uremia may not be identical in all patients, the components of the uremic syndrome include: (a) abnormalities in water, electrolyte, and acid-base metabolism particularly involving imbalances in potassium, sodium, acid-base concentrations, uric acid, chloride, calcium, magnesium, and phosphate; (b) abnormalities in cardiovascular functioning, especially including atherosclerosis, hyperlipidemia, hypertension, and pericarditis; (c) hemotologic abnormalities, most commonly anemia; (d) "renal osteodystrophy" which involves changes in the skeletal system from bone disorders primarily including osteitis fibrosa, osteosclerosis; (e) infections possibly from abnormalities in immune functioning; (f) neuropathy including abnormalities in both central and peripheral nervous system functioning; (g) myopathy commonly involving wasting of the limb or cervical muscles; (h) abnormalities in carbohydrate metabolism often involving
impaired glucose tolerance; and (i) hyperuricemia from the retention of uric acid (Kokko, 1985).

Treatment of CRF. The treatment of chronic renal failure generally involves either transplantation or intermittent dialysis. When transplantation is not imminent or contraindicated, treatment for chronic kidney failure usually involves dialysis, dietary management, and medication to replace the various functions of the kidneys. Dialysis is the purification of the blood by either extracorporeal dialysis, called hemodialysis which involves the use of an artificial kidney or peritoneal dialysis which utilizes the natural membrane lining the peritoneal cavity to conduct the dialysis procedures (Luke, 1985). The current discussion of dialysis will be restricted to extracorporeal dialysis or hemodialysis because the current study includes only these patients.

Hemodialysis is a procedure which uses an artificial kidney or dialyzer to perform some of the vital functions of the malfunctioning kidneys. The body's fluid balance is maintained by removal of excess fluid by a process called ultrafiltration. The artificial kidney also restores chemical balance and removes waste products through a process called diffusion. However, while the normal kidneys are continuously performing their vital functions, hemodialysis is typically conducted only three times each week for three to six hours per session (e.g.,
The artificial kidney, therefore cannot completely replace the functions of the normal kidneys. Between hemodialysis sessions, fluid and waste-products accumulate and electrolytes may become imbalanced. Therefore, dietary modifications are required to supplement hemodialysis and better control the accumulation of fluids, electrolytes, and waste-products in the blood. The dietary management of chronic renal failure (CRF) patients on hemodialysis usually involves the regulation of the intake of protein, sodium, fluid, and calories. Additionally, vitamin and mineral supplementation (e.g., B-complex, folic acid) is provided for dialysis patients since water-soluble vitamins are removed from the blood during dialysis (e.g., Rodriguez & Hunter, 1981).

**Importance of dietary modifications.** Compliance with dietary recommendations is very important for hemodialysis patients because deviations from the prescribed diet may result in a number of short- and long-term medical complications. The remainder of this section highlights a number of frequently prescribed dietary modifications for hemodialysis patients and the medical complications associated with deviations from these recommendations.

The major dietary modification in hemodialysis patients is the restriction of protein intake to prevent
or reduce the symptoms of uremia. The recommended daily intake of protein is 1.0 to 1.2 g/kg of body weight (Kluthe, Luttgen, Capetiance, Heinze, Katz, & Sudhoff, 1978). Blood urea nitrogen (BUN) is a waste product that accumulates in the blood from the breakdown of protein. A primary goal of dietary therapy is to maintain a BUN concentration below 90 mg/dl (Wolfson, 1984). Elevated BUN levels lead to some of the symptoms of uremia (i.e., azotemia) but many other substances are also responsible (Kokko, 1985). In addition, an adequate caloric intake must be maintained to spare endogenous protein from being used as a source of energy. The recommended daily intake of calories is 35 kcal/kg of body weight (Rodriguez & Hunter, 1981).

Potassium is a mineral necessary for the normal functioning of the nerves and muscles. Potassium is especially important in the normal functioning of the heart. Elevated potassium levels or hyperkalemia may produce cardiac arrhythmias and levels above 8 mEq/L may result in cardiac arrest (Andreoli, 1985).

Recommendations for fluid intake in hemodialysis patients are determined to maintain interdialysis weight gains (IWG) of 1.0 to 1.5 kg. The recommended daily fluid intake is the sum of a patient's remaining urine output and a 500-1000 cc allowance for insensible losses (e.g., evaporation from the respiratory tract; diffusion.
through the skin) (Rodriguez & Hunter, 1981). Excessive fluid intake may result in congestive heart failure and pulmonary edema (e.g., Robertson & Berl, 1986).

Sodium restrictions are important for patients with edema or hypertension but are not necessary for patients who do not experience hypertension or fluid overload. The recommended sodium intake is 87 to 172 mEq (i.e., 2-4 gm) and the failure to follow this recommendation and the frequently associated increased fluid intake may contribute to the experience of edema, hypertension, and congestive heart failure (Rodriguez & Hunter, 1981).

Calcium and phosphorus are two minerals important in the formation of bones. Kidney failure results in decreased calcium absorption and an accumulation of phosphorus in the blood (i.e., hyperphosphatemia). Hyperphosphatemia further contributes to decreased levels of serum calcium and may result in secondary hyperparathyroidism and renal osteodystrophy (Kokko, 1985). These problems are generally managed by prescribing phosphate-binding medications and instructing patients to avoid high phosphorus-content foods (Rodriguez & Hunter, 1981).

In summary, dietary modifications are a very important component of the comprehensive treatment of chronic hemodialysis patients. Compliance with these dietary recommendations is necessary to increase the
likelihood that the aforementioned short- and long-term medical complications associated with chronic renal failure can be reduced or prevented.

**Compliance in Health Care: Definition and Measurement**

The most commonly cited general definition of compliance was first presented by Haynes in a book entitled "Compliance in Health Care" (Haynes, Taylor, & Sackett, 1979). This definition describes compliance as "the extent to which a person's behavior (in terms of taking medications, following diets, or executing lifestyle changes) coincides with medical or health advice" (Haynes, 1979, pp 1-2). Even though Haynes provided a parsimonious general definition of compliance, the application of this definition to specific medical populations and medical regimens has not been an easy task for compliance researchers. Comparisons across investigations of compliance with medical recommendations is very difficult because tremendous inconsistencies exist in the operational definitions of compliance and the methods of measurement employed.

Rapoff and Christophersen (1982) provided the following rank ordering of general compliance measurement methods from most to least objective: assays (e.g., blood, urine), observation methods, pill counts, treatment outcome, physician estimates, and patient reports. The remainder of this section highlights each
of these measurement methods.

The use of biochemical methods of measuring compliance generally involves the random measurement of metabolic by-products of a drug or diet, the detection of a tracer placed in medication, or the presence of the therapeutic agent itself in blood or urine (Dunbar & Agras, 1980). Biochemical assays are believed to be the most objective and sophisticated measures of compliance with medications because they do not rely on subjective report (McKenney, 1979). Although physiological assessment methods have the advantage of being free of subjective report, they generally require greater cost and available technology to employ; are affected by variables other than compliance (e.g., metabolism); are of time-limited utility; and may be influenced by a patient's knowledge of the time of their occurrence (Dunbar & Agras, 1980; Rapoff & Christophersen, 1982).

Observational methods of measuring compliance involve the observation of the patient's compliance with the recommended regimen by another person who is in frequent contact with the patient (e.g., Azrin & Powell, 1969). Although this method of measurement is more direct and objective than most others, it is seldom used in research on compliance with medical recommendations because of the impractical demands of staff and time (Rapoff & Christophersen, 1982). Furthermore, this measurement
method may produce a reactive affect due to the observer's presence (Kazdin, 1973).

Pill counts or medication checks involve instructing the patient to return the container with the unused portion of their medication. The number of pills or amount of medication remaining is compared with the prescribed regimen to assess their medication compliance. Pill counts have the advantage of being relatively easy and inexpensive to conduct (Rapoff & Christophersen, 1982). Furthermore, evidence is accumulating that they are more accurate than patient reports of compliance (e.g., Park & Lipman, 1964; Rickels & Briscoe, 1970). Although pill counts are more direct, objective and practical than many methods of measuring compliance, they are of restricted application by their nature and have associated disadvantages as well. Research shows that pill counts tend to overestimate compliance (Agras & Jacob, 1979; Roth, Caron, & Hai, 1970) when compared with biochemical measures and do not aid in the identification of the pattern of error in compliance (Dunbar & Agras, 1980).

Treatment outcome is sometimes used as an indirect though objective measure of compliance. With this method, improvements in the clinical condition such as lowered blood pressure, normal blood sugar levels, or cessation of seizures, for example, are taken as an
indication of compliance with the medical regimen. The use of clinical outcome as a measure of compliance, however, is replete with problems. The most noteworthy of which is the undetermined relation between compliance and health outcome (Rapoff & Christophersen, 1982). For example, improvements in a patient's clinical condition may occur in spite of noncompliance with the regimen or behavior under investigation as a result of other influential factors such as concurrent treatment or nonmedical factors (e.g., socioeconomic status, positive attention or reassurance, psychological factors) (Gordis, 1979).

Physicians' global ratings of patient compliance are probably the most frequently employed and most practical method of assessing compliance for the practicing physician and are sometimes used as supplemental measures in research (Rapoff & Christophersen, 1982). This method generally involves having the physician provide a global rating of his patients' degree of compliance with a particular recommended behavior or treatment regimen. Research shows that this method of measurement has limited utility for both clinical and research purposes. Research on physicians' ratings indicates that physicians overestimate patient compliance and their estimates are no better than chance levels (e.g., Caron & Roth, 1968; Soutter & Kennedy, 1974). In one study, physician
ratings of compliance were found to be more accurate than patient reports but indicated significantly greater levels of compliance than did blood assays (Roth & Carson, 1978).

Patient self-report of compliance can involve patient interview or self-monitoring or both. Interviewing patients about their compliance is probably the most commonly used method of assessing compliance in the clinic (Dunbar & Agras, 1980). Although it is generally considered an indirect measure, it has the advantage of being more practical than many other methods, especially for the practitioner. However, the use of patient report to assess compliance suffers from many problems. There are numerous reasons why a patient may inaccurately report their compliance with medical recommendations, including for example, their memory or motivation to comply (Dunbar & Agras, 1980). Research indicates that compared with more objective measures such as urine assays, patients tend to underreport noncompliance with their prescribed recommendations (e.g., Haynes, Sackett, et al, 1976; Park & Lipman, 1964; Preston & Miller, 1964; Sheiner, Rosenberg, Marathe, & Peck, 1974).

The use of self-monitoring to measure compliance involves instructing patients to observe and record their regimen-related behavior on a daily basis. This method is subject to the same problems encountered with the use
of patient interviews and may also produce a reactive effect on the behavior being recorded (e.g., Romanczyk, 1974). Compared with the interview method, self-monitoring has the advantage of providing continuous information on compliance. Self-monitoring, therefore, can provide valuable information on the specific pattern of compliance with the recommended regimen and help identify problems in performing the regimen-related behaviors.

**General Definition of Compliance in Hemodialysis Patients**

One of the major criticisms of the compliance literature in general is the wide variety of definitions of compliance employed across investigations. A number of variables may affect the particular definition used within a study, including for example, the patient population, the type of medical regimen, and the measurement methods employed. Unfortunately, even focusing on a specific patient population or medical regimen may not eliminate this problem. Even in the narrow body of literature specifically addressing dietary compliance in hemodialysis patients, a wide variety of operational definitions of compliance are employed.

A general definition of compliance in dialysis was presented by Czaczkes and Kaplan De-Nour in 1978. These authors described three subdivisions of compliance in dialysis. One type involves *general compliance* with such
recommendations as taking medications and undergoing routine medical tests. The second subdivision involves compliance with diet, especially with recommendations for potassium, protein, and fluid intake. The third proposed subdivision involves compliance with the dialysis procedure. This division is proposed to include cases in which a patient chooses to terminate dialysis treatment against medical advice. The current study focused on the former two subdivisions of compliance proposed by Czaczkes and De-Nour with the major emphasis on dietary compliance. The term compliance is generally used in the dialysis literature to represent compliance with diet, taking phosphate-binding medications and attendance at dialysis sessions (e.g., Ferraro, Dixon, & Kinlaw, 1986).

Before focusing on the methods of measuring compliance employed in the dialysis literature, a brief overview of the commonly employed dependent variables will be presented. Research on compliance in dialysis patients has involved a variety of dependent variables, some of which are more direct measures of dietary compliance, some of which are indirect measures of dietary compliance, and one of which is primarily a measure of medication compliance. Research on dietary compliance in dialysis has generally included any one or combination of the following dependent variables: interdialysis weight gain (IWG), blood urea nitrogen.
(BUN) levels, creatinine levels, serum potassium (SP) levels, serum phosphorus levels, and predialysis blood pressure. (See Table 1). Of the four most commonly employed dietary compliance variables, SP, IWG, and BUN are generally considered direct measures of dietary compliance and serum phosphorus reflects compliance with phosphate-binding medication and dietary intake of phosphorus.

Methods of Measurement

The measurement of compliance in dialysis has generally involved the use of three exclusive methods of measurement including: patient self-report, subjective ratings by health professionals, physiological (e.g., biochemical) assessments, and/or combination methods (e.g., health professionals' ratings based on a review of physiological measures). The remainder of this section highlights the use of each of these measurement methods of evaluating compliance in dialysis patients. Furthermore, empirical findings on the reliability and validity of these methods are presented.

Self-report. Several researchers have used semi-structured interviews to collect information on compliance in dialysis patients. Kaplan De-Nour and Czaczkes (1972) obtained qualitative information on patient compliance during interviews which focused on factors believed to influence adjustment to chronic
dialysis. A number of other investigators employed the interview as a method of measurement but attempted to collect quantitative information on patient compliance. Incorporated into more general interviews, patients were asked to rate their compliance with the three components of their medical regimen (Cummings, Becker, Kirscht, & Levin, 1982; Cummings, Kirscht, Becker, & Levin, 1984; Sherwood, 1983). Specifically, the patients rated their compliance with dietary recommendations, phosphate-binding medication, and fluid restrictions using a 5- or 7-point Likert-type response scale.

Subjective ratings by health professionals. Four studies have employed health professionals' judgments or ratings as a method of measuring compliance in dialysis patients (Armstrong & Woods, 1983; Blackburn, 1977; Cummings et al., 1984; Schlebusch & Levin, 1982). The only information that Schlebusch and Levin (1982) provide on their method of measurement is that their subject sample was classified into compliers or noncompliers by staff based on the patients' compliance with their medical regimens. The method employed by Blackburn (1977) involved having several health professionals including nurses, dialysis technicians, and a dietitian rate each patient as to whether they were compliant at least half of the time with potassium, phosphorus, and between dialysis weight gain recommendations. Cummings
and colleagues (1984) instructed nurses to rate the degree to which patients complied with phosphate-binding medication, dietary restrictions, and fluid intake recommendations. These ratings were made using a 7-point Likert-type scale with responses ranging from "poor" to "excellent". Armstrong and Woods (1983) had six health care professionals, subdivided into physicians and nonphysicians, rate patients on general compliance using a 5-point Likert-type scale.

Physiological assessment. The majority of the researchers in this area have employed physiological assessments as the single method or as one of multiple methods of measuring compliance. This method of measuring compliance involves reviewing the patients' medical records for the values of the objective physiological parameters of concern. Investigators employing this method have measured a variety of indices of compliance. (See Table 1). Many authors have collected measures of interdialysis weight gains and two biochemical parameters, potassium and phosphorus, as indices of compliance with dietary recommendations and phosphate-binding medication (Armstrong & Woods, 1983; Blackburn, 1977; Cheek, 1982; Cummings et al., 1982; Cummings et al., 1984; Sherwood, 1983; Yanitski, 1983).

Several studies primarily concerned with compliance with dietary recommendations measured IWG and one of two
biochemical parameters, SP or BUN (Bollins & Hart, 1982; Cummings et al., 1981; Finn, Alcorn, Hollandsworth, & Hendler, 1985; Hart, 1979; Magrab & Papadopoulou, 1977; Procci, 1978; Procci, 1981). Other investigators employing this method of measurement have included single physiological parameters especially IWG (Agashua, Lyle, Livesley, Slade, Winney, & Irwin, 1981; Keane, Prue, & Collins, 1981; Yanagida, Streltzer, & Siemsen, 1981) or multiple measures which included both the aforementioned direct measures along with others such as creatinine and/or sodium and indirect measures of compliance especially blood pressure (Barnes, 1976; Basta, 1981; Ferrararo, et al., 1986; Seime, 1980).

Combination methods. In addition to the aforementioned methods, several studies have involved a method which combines medical staff or investigator judgment with physiological assessments to measure compliance in dialysis patients. This combination method employing staff ratings based on physiological assessment measures was first employed by Kaplan, De-Nour, and Czaczkes (1972). This method involved having a health professional, usually the attending nephrologist, rate each patient on their degree of compliance after reviewing the patients' medical records on the physiological parameters of compliance. The three physiological parameters of primary concern were
interdialysis weight gains, potassium values, and BUN values. The global compliance rating was made on a 5-point scale ranging from "excellent" to "great abuse". (See Appendix A). This method has continued to be employed in the same form (Poll & Kaplan De-Nour, 1980) or a modified form including a 3-point compliance rating scale (Kaplan De-Nour & Czaczkes, 1976). Furthermore, it is interesting to note that what some researchers (e.g., Cummings et al., 1984) are considering health professional judgments of compliance may actually be more accurately referred to as a combination method because staff have access to patients' physiological records when judging compliance.

Another type of combination method was employed by Hartman and Becker (1978). This method of measuring compliance involved having investigators rate the patients' degrees of compliance on a 7-point scale based on a review of the patients' values on three physiological measures including potassium, phosphorus, and IWG.

Empirical Evaluations of these Methods

Unfortunately very little has been done empirically to evaluate the various methods of measuring compliance in dialysis patients. A few studies, however, have addressed the issue of the accuracy of their measurement method in the course of a more comprehensive study.
Blackburn (1977) for example, compared staff ratings of compliance with "actual compliance" values as measured by physiological assessment methods. Although no statistical analyses were performed, the authors concluded that the staff ratings tended to be accurate. Visual inspection of the tabular presentation of this information indicates that the means across health professionals of the percentage of patients classified as compliant for each variable are similar to the percentages classified as compliant using physiological parameters. Much variability exists, however, across the health professionals. Additionally, it is noteworthy that these researchers employed the compliance classification obtained from the physiological assessment method as the standard or "actual compliance" values by which the staff ratings were evaluated.

Armstrong and Woods (1983) evaluated the accuracy of the subjective ratings of six health professionals using (a) Pearson correlations, (b) Lawlis and Lu chi-square analyses of specified rater-pairs, and (c) intraclass correlations under varying assumptions. Based on the results of these analyses, the authors conclude that "subjective compliance ratings should be made only by teams of raters, not by single observers" (Armstrong & Woods, 1983, p. 84). Furthermore, they mentioned that compared with the compliance classifications based on the
objective physiological assessment method, they achieved an 80% overlap in group selection using the composite ratings of six health professionals but would have had very different results had single raters' subjective judgments been used.

Only one study to date had been conducted with the primary goal of investigating the accuracy of various methods of measuring compliance in dialysis patients (Cummings et al., 1984). These researchers employed a multitrait-multimethod design to assess the construct validity of the three commonly used methods: physiological assessments, health professional ratings, and patient self-report. The "traits or behavior classes included in this study were three types of compliance behavior: taking phosphate-binding medication, following dietary recommendations for potassium intake, and following recommendations for fluid restrictions. (See Table 2).

These authors applied a sophisticated structural analysis method to investigate their multitrait-multimethod matrix. This method employs a maximum-likelihood procedure to partition the variance for each measure into: (a) valid variance which reflects what the measure is intended to measure, (b) correlated error variance (i.e., method variance) which reflects influences other than those the measure was intended to
measure which also affect other measures, and (c) residual variance which reflects the portion of variance not accounted for with valid or correlated error variances. The results of this analysis procedure indicate that the nurse-report method contained approximately 50% valid variance, the physiological assessment method contained 23% valid variance and the patient self-report contained 12%. Furthermore, the percentage of total variance attributable to method effects was approximately 35% for the nurse-rating method, 18% for patient self-report, and 5% for the physiological assessment method. Residual error variance was approximately 11% of the total variance for the nurse-rating method, 60% for the patient self-report method, and 72% for the physiological assessment method.

A number of flaws are present in this study which seriously limit the utility of these results. For example, the authors themselves point out that they violated the assumption of independence among measurement methods because the nurses had access to the physiological assessment information in the patients' medical records. Additionally, the two subjective methods of measurement were similar in that each involved subjective ratings on a 7-point Likert-type scale whereas the physiological method employed raw values. Furthermore, the authors incorrectly constructed their
MTMM matrix making visual inspection of their data difficult. After reconstructing their matrix in the manner suggested by Campbell and Fiske (1959), a number of problems were evident. (See Table 3). The authors incorrectly presented perfect correlations (i.e., \( r=1.00 \)) along the "reliability diagonals" indicating that measuring the same "trait" with maximally similar methods (e.g., test-retest) resulted in perfect reliability. The authors, however, made no mention of performing reliability estimates on their measurements and if they had, it is unlikely that they would have achieved perfect correlations. This inadequacy places severe limitations on further interpretation of the data because it is difficult to further examine these measures without knowledge of their reliability.

Furthermore, the results presented in the MTMM matrix did not meet the minimal criteria established by Campbell and Fiske (1959) as evidence for convergent and discriminant validity. The requirement for convergent validity is that the correlations along validity diagonals must be statistically significant and sufficiently large to warrant further examination of validity. Three criteria must be met for evidence of discriminant validity. These include (a) each correlation along the validity diagonals should be larger than the values in the same column and rows of the
heterotrait-heteromethod triangles, (b) each value in the validity diagonals should be larger than all values in the corresponding heterotrait-monomethod triangle, and (c) all heterotrait triangles should indicate the same pattern of trait interrelationships. Visual inspection of the present author's reconstruction of the MTMM matrix indicates that the values do not meet these criteria and therefore, do not indicate convergent and discriminant validity. Therefore, although the work of Cummings and colleagues (1984) is meritorious for its attempt to study the construct validity of common methods of measuring compliance, the inadequacies in their methodology make their findings equivocal at best.

No investigations have been conducted with a primary goal of determining the stability of these dietary compliance measures and only two studies have even addressed this issue. In the course of an investigation of the influence of personality on adjustment to dialysis, the authors evaluated the influence of time on compliance (De-Nour & Czaczkes, 1976). In this study one hundred patients were followed for four years after commencing dialysis. A number of variables were assessed at six-month, 1-year and 2-year followup, including psychological condition, vocational rehabilitation, and dietary compliance. In an attempt to determine which followup measures should be used for the analyses, the
authors investigated the influence of time on compliance. A comparison was made on 6-month, 1-year, and 2-year compliance measures for 51 patients. The authors reported that they obtained correlations of high statistical significance and concluded that there is no change in compliance across followup periods. These results must be accepted cautiously because the authors did not present the actual results of their statistical analyses.

One other investigation has been found to address indirectly the issue of temporal stability of dietary compliance measures (Agashua et al., 1981). Although these investigators were primarily concerned with the accuracy of predicting dietary compliance based on two different criteria for compliance with weight gain, they evaluated the stability of their mean compliance measures across time. These authors derived Pearson correlation coefficients on the mean of 20 interdialysis weights (over approximately 7-10 weeks) for each patient's first twenty dialysis sessions and previous twenty at the time of the study. They reported a significant positive correlation between these two mean measurements and conclude that "time had no appreciable effects" on compliance variability. Although this study has important heuristic value because it highlights the importance of addressing the temporal stability of compliance measures employed, it does not provide the
definitive answer to this question. First, the study contained a methodological flaw in evaluating temporal stability, i.e., the time from the first and second measurement periods ranged from four months to greater than six years for different patients. Therefore, it is imperative that further methodologically sound investigations be conducted to determine the temporal stability of compliance as measured by physiological assessment methods before a definition of compliance can be formulated using these measures.

Operational Definitions of Compliance in Dialysis Patients

It is difficult to provide a general overview of the operational definitions of compliance in dialysis patients because the number of operational definitions available almost equals the number of studies conducted in this area. Even researchers who have published multiple studies on compliance have been found to change their definition of compliance (e.g., Procci, 1978; Procci, 1981; Kaplan De-Nour, & Czaczkes, 1972; Kaplan De-Nour, & Czaczkes, 1976) from one study to another.

Studies involving patient self-report or subjective medical staff ratings of compliance have not presented the specific criteria employed to determine compliance. These studies generally involve a dichotomous rating of compliant/noncompliant (e.g., Blackburn, 1977) or ratings
of the degree of compliance on a Likert-type response scale with anchors ranging from poor to excellent, for example (e.g., Cummings, et al., 1984).

Most researchers in this area have employed physiological assessment measures to define compliance. Even with this method of measurement, much variability exists in the operational definition of compliance employed. (See Table 1). These studies include differences in the unit of time over which compliance is measured, the summary statistic employed, and the cut-off values for compliance. These differences are elucidated in the remainder of this section.

The unit of time over which physiological assessment measures of compliance were collected ranged from a single week (e.g., Cummings, et al., 1984) up to a 14-month period (e.g., Blackburn, 1977). Some investigators used a mean value to summarize the data collected and determined patients' compliance classifications by comparing their mean value for each compliance parameter to a specified range or upper cut-off value indicating compliance (e.g., Cummings et al., 1982; Procci, 1978). Other investigators examined the percentage of time a patient's physiological values fell within a specified range or below an upper cut-off to determine their compliance level (e.g., Blackburn, 1978; Cheek, 1982; Yanagida et al., 1981).
In one study (Armstrong, & Woods, 1983), the authors employed a unique approach to defining compliance. These researchers determined the slopes across two repeated measures of three physiological parameters of compliance. Patients were rank ordered by mean slope for each of the parameters and three compliance groups were selected based on these rankings. The "compliant" group included 20 patients with the lowest ranks across the three parameters and the "noncompliant" group included 20 patients with the highest ranked slopes across the three parameters. A third group, the "crazy-quilt" group included 10 patients who had widely discrepant ranks. This group was included to investigate those patients who were compliant on some parameters and noncompliant on others.

The criterion ranges or cut-off levels employed to define compliance even varied considerably across studies when the same physiological parameter was employed. The upper cut-off for potassium which indicated compliance ranged from 5.0 mEq/L (e.g., Blackburn, 1977; Cheek, 1982; Hart, 1979) to 6.0 mEq/L (e.g., Procci, 1978). The upper cut-off for phosphorus ranged from 4.5 mg/100 ml (e.g., Cheek, 1982) to 5.5. mg/100 ml (e.g., Cummings et al., 1982). The upper cut-off criteria for compliance using INW as the physiological parameter generally ranged from .9 kg (Procci, 1978) to 3.0 kg (e.g., Cummings, et
al., 1982). The idiosyncratic criteria for IWG set for individual treatment cases indicated even greater variability, ranging from .45 kg (Finn et al., 1985) to 3.5 kg (Keane, et al., 1981). Only one study described the upper cut-off criteria for compliance with BUN, that is, 100 mg percent (Basta, 1981) and no criteria have been presented for other physiological parameters employed to measure compliance such as creatinine or sodium.

Most researchers employed a dichotomous classification of their patients such as compliant-noncompliant or good-poor compliers. The work of Kaplan De-Nour and Czaczkes (1972), however, deserves special coverage because these authors developed a comprehensive set of criteria which classifies patients into groups based on different degrees of compliance (See Appendix A). Patients received a compliance rating ranging from "excellent" to "great abuse" of diet based on the percent of time their values on three physiological parameters fell within specified ranges. For example, "excellent" compliance was operationally defined as IWG never above 500 g; predialysis serum potassium levels never above 6 mEq/L and most of the time less; and steady predialysis BUN levels. These criteria for compliance have been employed by other researchers, both in the same form (Poll, & Kaplan De-Nour, 1980) or in a modified form.
Incidence of Compliance in Hemodialysis Patients

The aforementioned problems in defining and measuring compliance, both in general and specifically in hemodialysis patients, limit the accuracy in the reported estimates of the incidence of compliance. With this caution in mind, a brief overview of reports of the incidence of compliance in hemodialysis patients will be presented. An early report of the incidence of dietary compliance was provided in a study by Kaplan De-Nour and Czaczkes (1972). These authors employed a five-point scale which incorporated criteria for each of three dietary compliance measures, BUN, SP, and IWG. Based on their criteria, they found that 12% of 100 patients were "excellent" compliers, 23% were "good" compliers, 19% were "fair" compliers, 30% had "some abuse" of their diet, and 16% had "great abuse" of their diet. In another study these same authors (Kaplan De-Nour & Czaczkes, 1976) modified their criteria to a three-point scale incorporating the same three measures. Based on these criteria, they found that 39% were "bad" compliers, 38% were "fair" compliers, and 23% were "good" compliers.

Studies which reported separate incidence rates for compliance with different dietary recommendations have indicated much variability in compliance rates for both
the same dietary recommendation and across dietary recommendations. The percentage of compliant patients has ranged from only 7% who were classified compliant based on their phosphorus levels (Cheek, 1982) to 97% who were classified compliant according to their potassium levels (Procci, 1978). The percentage of patients who were considered compliant across studies based on potassium levels ranged from 33% (Cheek, 1982) to 97% (Procci, 1978) with a median of 84.5% (Procci, 1978; Yanitski, 1983). The percentage of patients considered compliant across five studies based on phosphorus levels ranged from 7% (Cheek, 1982) to 65% (Yanitski, 1983) with a median of 39% (Hartman, & Becker, 1978). Patients considered compliant across nine studies based on IWG ranged from 30% (Yanitski, 1983) to 78% (Hartman, & Becker, 1978) with a median of 53% (Bollin, & Hart, 1982). No information is available on the incidence of compliance with other aspects of dialysis dietary recommendations such as sodium restrictions.

In summary, the previously mentioned problems in this body of literature preclude drawing any confident conclusions about the incidence of compliance in hemodialysis patients except, perhaps, that no matter how you measure or define noncompliance in this population, it does appear to be a significant problem. Before attempting to estimate the incidence of noncompliance,
future researchers should first focus on accurately defining and measuring this construct in hemodialysis patients.

The remainder of this review presents the literature on the role of dietary compliance in survival for dialysis patients and presents a rationale and methodology for the present investigation.
Rationale for the Invention of the Problem

This investigation was designed to gain knowledge of the role that dietary compliance plays in the survival of hemodialysis patients. As a result of this kind of research, health care professionals may better understand the individual and collective influence that various aspects of dietary compliance have on survival. This knowledge would also help in the identification and intervention of dietary noncompliance in hemodialysis patients.

Dietary management is an important component of the comprehensive treatment of chronic renal failure (CRF) because failure to maintain these recommendations is believed to result in increased medical complications and in some cases of extreme elevations (e.g., elevated potassium), immediate death may ensue (e.g., Siddiqui, Fitz, Lawton, & Kirkendall, 1970). Although some research has been devoted to the investigation of variables that influence compliance in dialysis patients and to the evaluation of interventions designed to improve compliance, only one published study to date even indirectly addressed the relation between dietary compliance and survival.

The only research which investigated the relation between dietary compliance and survival in dialysis patients was reported by Czaczkes and Kaplan De-Nour in a
book entitled "Chronic Hemodialysis as a Way of Life" (1978). The authors summarize variables which influence survival on dialysis, including one paragraph devoted to a research project on dietary compliance. This paragraph presents the results of a 5-year study in which they found that of the patients who were still living after five years, 28% had complied well with their diet including fluid restrictions, 51% complied fairly well, and 21% "abused" their dietary recommendations. Of those who died on dialysis, 58% abused their diet, 24% complied fairly well, and 18% complied well with their diet. These authors report a significant chi-square analysis on their results and conclude: "We have, therefore, been able to prove the obvious, i.e., that compliance with the diet does influence survival" (p. 123). Surprisingly, this is the only reference that can be found on this study. Needless to say, the conclusions Czaczkes and Kaplan De-Nour made were high inference given their reported data. Furthermore, they do not provide any information on the methodology of this study to allow one to evaluate the quality of their research. Specifically, acceptance of their conclusions would be facilitated by some knowledge of their sample characteristics and size, the specific dependent variables they employed, and their method of measuring these variables. Unfortunately, even though the results of the survival study presented by
Czaczkes and Kaplan De-Nour (1978) appear equivocal, subsequent dialysis researchers (e.g., Seime, 1980) have cited these results as evidence for the relation between compliance and survival in dialysis patients.

Fortunately, other researchers have not accepted these results as conclusive and have even indicated the need for further research in this area. For example, Armstrong and Woods (1983) stated: "We note that all the noncompliance-in-hemodialysis literature is predicated on the notion that noncompliance decreased one's chances of medical survivorship. We know of no study that documents this presumption based on survivorship analysis" (p. 91). Although Armstrong and Woods (1983) ended their discussion with this quote, they had begun their introduction by stating: "It is universally assumed among health professionals in nephrology that compliance to diet and fluid restrictions predicts survival in chronic dialysis" (p. 79). This statement led the present author to wonder if these health care professionals in nephrology had identified another source of data to support this assumption outside of the literature on compliance in dialysis. In an attempt to determine if the question about the relation between compliance and survival had been answered within another area of dialysis literature, the research on survival in dialysis patients was examined.
The anticipated data to support the assumption that dietary compliance predicts survival was not forthcoming. First, investigations conducted before 1973 or which included a large population of their sample from patients who began dialysis before this year were eliminated from consideration. The main reason for their exclusion is that Medicare began providing coverage for dialysis in 1973, thus relaxing the criteria for chronic hemodialysis. That is, prior to 1973, a very restricted sample of individuals received dialysis. Since then, almost any patient may receive dialysis. Additionally, it is beneficial to exclude the results from earlier years because medical technology has greatly improved (e.g., McBride, 1984) over the early years since the initiation of hemodialysis as a method of treatment in 1961. These changes in patient sample and dialysis procedures present a confound in the interpretation of the research evaluating the variables which influence survival.

Early studies which addressed the issue of compliance in survival, however, should not be completely disregarded. For example, one study described the characteristics of 25 patients who survived on dialysis for 14 or more years up to 1981 (Guttman, 1983). This study involved selection bias because at the time of initiation of dialysis for these patients, patients were
chosen for dialysis by fairly subjective and restricted criteria based on their expected success or survival on dialysis. Despite this methodological flaw, the author's description of the characteristics of these long term "survivors" includes biochemical measures of phosphorus and interdialysis weight gains. These measures indicate that the survivors were generally compliant with these aspects of their regimen.

Two recent studies on factors influencing survival in dialysis patients have included biochemical measures indicative of dietary compliance. Unfortunately, these studies, like those including patients who began dialysis before 1973, involved selection bias because they include only home-dialysis patients. Like patients receiving dialysis in the formative years, home dialysis patients are chosen on fairly subjective criteria usually involving their available resources and their predicted adjustment and survival with this procedure. One study (Wai, Burton, Richmond, & Lindsay, 1981) investigated the effects of psychosocial, demographic, and physiological variables on survival. A number of variables were assessed in 285 home-dialysis patients (178 with hemodialysis; 82 with continuous peritoneal; 25 with intermittent peritoneal) and these patients were followed over a minimum of 18 months. At the followup period, surviving patients were compared to deceased patients on
a number of variables including physiological (e.g., biochemical) indices of dietary compliance. The data were analyzed using t-tests and the results indicated significant differences between the deceased and survivors on age, depression, and a biochemical measure of health status (i.e., Albumin). The last two measures, however, were of marginal statistical significance. It should be noted that if Bonferroni's procedure had been employed to correct for inflated Type I error due to multiple pairwise comparisons, these two variables would not have indicated significant differences between the groups. Furthermore, it is important to reiterate that no differences were found between the groups on physiological indices of dietary compliance including weight gain and protein levels. In spite of the above mentioned results, however, the authors performed a discriminant function analysis on all of their variables. They report that the results of this analysis indicate that age and depression are the best discriminators but IWG, hemoglobin levels and total protein levels also discriminated survivors from non-survivors.

A careful review of the analyses and results of the Wai et al. (1981) study indicates a serious flaw. Although the authors report they obtained a significant discriminant function, it appears that they used equal probability levels for their groups and neglected to take
the number of subjects in each group into account. If they had employed prior probabilities which account for the size of each group, their classification accuracy would have been at less than chance level. Although this study contains some methodological flaws and includes a biased sample, the finding that the two groups did not differ on the compliance variables measured suggests that further study is needed to evaluate the influence of dietary compliance on survival.

Other researchers (Richmond, Lindsay, Burton, Conley, & Wai, 1982) examined psychological and physiological factors in adjustment and survival with home-dialysis patients. These researchers compared the surviving and deceased groups on a number of physiological parameters including several indices of dietary compliance: SP, BUN, phosphorus, and IWG. The patients were followed for approximately 2 years and then the survivors and deceased groups were compared using Student's t-tests or chi-square analyses on each of the variables under study. The authors failed to find significant differences between these groups on any of the variables measured. Although these results cannot be generalized to all hemodialysis patients, they provide some data to challenge the assumption that dietary compliance influences survival in hemodialysis patients.

The largest study to date on survival rates in
hemodialysis patients included all patients in the United States who began receiving medicare coverage for the treatment of end-stage renal disease between 1973 and 1982 (Krakauer, Grauman, McMullam, & Creede, 1983). Although this study provides primarily descriptive information, it is valuable because it includes the most comprehensive sample (N=62,270 dialysis patients). The study provides descriptive information on three demographic variables, age, sex, race, and on the primary disease which resulted in CRF. Furthermore, the percentage of 1- and 3-year survival rates for each of these variables is mentioned. Although this information was not subjected to statistical analysis, visual inspection indicates that there was a trend toward decreased survival rates with increased time on dialysis and for adult patients (i.e., 21 years old or older) there was decreased survival rates with older ages of initiation of dialysis. Although this study provided valuable descriptive information on survival rates, no information was collected on dietary compliance variables for these patients.

Another team of researchers (Hellerstedt, Johnson, Ascher, Kjellstrand, Knutson, Shapiro, & Sterioff, 1984) investigated the survival rates of 2728 patients with CRF, more than 1000 of whom were being treated with in-center dialysis. This study investigated the affects
of the following risk factors on survival: age at onset of therapy, race, sex, provider of health care, primary cause of renal disease, concomitant morbid conditions at onset of therapy, and treatment mode. The results indicated that age of onset of treatment for CRF significantly affected survival rates. In general, survival rates were lower for diabetics than nondiabetics. Furthermore, primary diagnosis at the onset of treatment and concomitant morbid conditions were found to influence survival rates. Again, no consideration of dietary compliance was included in this study.

Since the review of the literature had not provided a conclusive answer about the role of dietary compliance on survival in hemodialysis, the present investigation was an attempt to address this important question.
Rationale for the Solution of the Problem

Since the central problem in this proposed investigation was to elucidate the role that dietary compliance plays in the survival of hemodialysis patients, a method was needed whereby the relation between these variables can be examined. To date this problem had not been addressed in a methodologically sound way. Thus, the current investigation needed to integrate the information provided in the methods and findings of the previous work on compliance in dialysis patients to provide clarity on the relation of diet to hemodialysis survival.

One important weakness in previous investigations was subject selection. Many investigations involved small sample sizes and/or heterogeneous samples. Some researchers even neglected to provide any descriptive information on their subject population. These problems make interpretation of their findings and comparisons across studies difficult, if not impossible. The current investigation was designed to include an adequate sample size to perform the necessary statistical analyses and enhance generalization of findings. Subjects were to be selected on the basis of a number of variables deemed important by a review of the literature and by suggestions from a dietitian and physician at the dialysis centers involved in the current study.

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Specifically, patients were to be chosen who have a similar renal diet (See Appendix B and C for samples of portions of the renal diet), have the same remaining urine output function, are receiving the same dialysis treatment (i.e., in-center hemodialysis), and have been on dialysis for at least 3 months.

The patients were not to be matched on relevant demographic or medical variables because this would result in a great reduction in the possible total sample size eligible for inclusion in this study. A number of demographic and medical history variables were to be measured and considered for inclusion in the analyses as predictor variables. The demographic variables were to include age, sex, and race. The recent literature in this area suggests that the following medical history variables may be important to survival: age of initiation of dialysis (e.g., Hellerstedt, 1984), duration of time receiving dialysis (e.g., Guttman, 1983), and number of concurrent diagnoses (Bruce, 1986). These demographic/medical variables were to be measured and included in the analyses in order to determine and statistically control for their influence on survival. This will be further explained in the analyses section.

Furthermore, to control for differences in treatment of the patients by medical staff that would be the case if different dialysis centers would be included, the
patients were to be selected from those receiving dialysis at two centers in Baton Rouge, Louisiana. These two centers were to be included because they are managed by the same corporation and are staffed by the same physicians, dietitian, social worker, and psychology personnel. Therefore, the treatment procedures and care in these centers are highly comparable.

Three physiological parameters of dietary compliance were to be measured in the proposed study: blood urea nitrogen (BUN), serum potassium (SP), and interdialysis weight gain (IWG). These three parameters were chosen for use in this investigation for the following reasons. The review of the literature in this area indicated that these parameters have been the most commonly employed measures of dietary compliance in hemodialysis patients. In addition, these parameters are measured routinely at the dialysis centers included in the current study and are important components in the recommended dietary regimen of the patients at these centers (See Appendices B and C).

The current investigation was designed to involve the physiological assessment method of measuring dietary compliance instead of other methods of measurement (e.g., self-report, staff ratings) because: (a) the literature indicates that physiological measures of dietary compliance are the most commonly employed measures in
hemodialysis patients, (b) these measures are commonly employed by dietitians and physicians for the purpose of clinically evaluating dietary compliance in dialysis patients, (c) compliance researchers believe that physiological measures are the most objective method of measurement (see section on Compliance in Health Care: Definition and Measurement), and (d) no alternative methods of measuring dietary compliance in hemodialysis patients have been well-developed or well-researched and (e) the methodology of this study precluded the use of self-report or staff-report measures.

Since no standard unit of measurement had been indicated by the literature and the stability of dietary compliance as measured by physiological methods has not been well-investigated, a pilot study was conducted by the author to determine the unit of measurement to employ with the three compliance parameters. Statistical analyses were performed to evaluate the stability of the means of monthly measures across time periods of 3 months, 6 months, and 1 year. Bivariate correlations were performed on the measures for 3-month means, 6-month means, and 1-year means for these three compliance parameters. (See Table 4). The results indicated very low nonsignificant to high significant correlations among the 3-month means for all 3 dietary compliance parameters. The results of the 6-month means indicated
significant high correlations for BUN and SP, but very low nonsignificant correlations for IWG. The bivariate correlations of the 1-year means indicated significant moderate to high correlations for all three parameters. Therefore, in the current investigation I planned to use a 1-year mean as the unit of measurement because it indicated adequate levels of stability for all 3 dietary compliance parameters included in this study. The results of this pilot investigation offer empirical support for a recent suggestion by Ferraro and colleagues (Ferraro et al., 1986) that researchers in this area should use the mean of multiple observations when using physiological measures to avoid defining compliance with single and possible atypical measurements.
Questions Investigated and Predicted Outcomes

The proposed study addresses three major questions:

**Question 1.** What is the relation of physiological parameters of dietary compliance to survival in hemodialysis patients?

**Question 2.** What is the accuracy of physiological parameters of dietary compliance as predictors of survival relative to that of important demographic/medical variables?

**Question 3.** Given that demographic/medical variables generally cannot be manipulated, how well do the physiological parameters of dietary compliance collectively discriminate between the deceased and survivors on hemodialysis? Furthermore, are some physiological parameters of dietary compliance better predictors than others?

Based on the past research and the given parameters of the present study, the following three major predictions will be tested.

**Predictions based on Question 1:** (a) If measures of the parameters of dietary compliance (BUN, IWG, SP) are important in the treatment of hemodialysis patients, these measures will be at least moderately and significantly correlated to the criterion variable of survival. (b) Measures of BUN, IWG, and SP will be related differentially to the criterion variable.
Predictions based on Question 2: (a) Given measures of the parameters of dietary compliance are important in survival, these measures will add significantly to the discrimination of survival groups compared to the demographic/medical variables. (b) The combination of the demographic/medical variables and the dietary compliance variables will collectively discriminate between the survivors and deceased groups at better than chance levels.

Predictions based on Question 3: (a) Given the measures of dietary compliance are important in the prediction of survival, they will collectively discriminate between surviving and deceased hemodialysis patients at better than chance levels. (b) Measures of BUN, IWG, and SP will differentially discriminate between the survival groups.
METHOD

Subjects

This investigation included all eligible patients from two hemodialysis centers in Baton Rouge, Louisiana. Two patient groups were selected for inclusion. All patients who were on dialysis between January 1982 and December 1982 were screened for inclusion in the current study. Subject selection was based on the following inclusion criteria: (a) treatment recommendations for kidney failure included in-center hemodialysis procedures three times each week, (b) a renal diet including recommendations for sodium, potassium, protein, and fluid intake, (c) negligible or no remaining urinary output, and (d) dialysis treatments for at least three months.

A total of 123 patients were screened for inclusion in the current study. Of these patients, 110 met the inclusion criteria and 13 did not for a number of reasons including the following: (a) receiving transplants, (b) transient lifestyle including only brief treatment at the Baton Rouge dialysis centers, (c) transferral to another dialysis clinic, and (d) insufficient data.

Patients who died between January 1982 and June 1986 comprised the "deceased" group and all patients who were still alive until June 1986 comprised the "survivors". Of the 110 patients included in this study, 40 were survivors and 70 were deceased (see tables 5-7 for
subject characteristics).

At the time of the study, the subjects ranged in age from 20 years 6 months to 78 years 1 month with a median age of 53 years 3 months. This sample included 57% male, 43% female, 66% black, and 34% white patients. The majority, i.e., 64% were married, 10% were single, and 26% were separated, divorced, or widowed. Chi square analyses indicated no differences between deceased and survivors on sex or race but ANOVA analyses indicated that the groups differed significantly on age ($F(1,107) = 5.6651$, $p<.02$). Specifically, the average age of the deceased group was higher than that of the survivor group.

The range of age of onset of dialysis treatment was 9 years 6 months to 76 years 10 months with a median of 50 years 2 months. Number of years on dialysis at the time of the start of the study (i.e., January, 1982) ranged from 10 months to 18 years 1 month with a median of 3 years. The present sample included 17% of patients with no concurrent diagnoses in addition to renal failure, 49% with one, 25% with two, 8% with three, and 1% with four concurrent diagnoses. Chi square and analysis of variance analyses indicated no differences between groups on age at onset, years on dialysis, and number of concurrent diagnoses.

The duration of time patients survived on dialysis
from onset until the end of the study (i.e., June, 1987) ranged from 7 months to 21 years 6 months with a median of 6 years 4 months. The age at which patients died ranged from 23 years 7 months to 80 years 4 months with a median of 57 years 5 months. Of the deceased group, the cause of death for 45% was cardiac-related (e.g., MI, pericarditis), 10% was a cerebrovascular problem, 15% was infection, 9% was unknown causes, 6% was malignancy, and 15% was miscellaneous other causes.

Research Variables

Predictor variables. The predictor variables included three physiological measures of dietary compliance and a number of demographic/medical history variables. The three physiological variables were measures of serum potassium (SP), blood urea nitrogen (BUN), and interdialysis weight gain (IWG). Demographic/medical variables included age, sex, race, age at onset of dialysis, years on dialysis, and number of concurrent diagnoses.

Age at onset of dialysis was a patient's age in years at the time of the first chronic dialysis treatment. Years on dialysis was the total number of years from a patient's first chronic dialysis treatment until January 1982. The number of concurrent diagnoses was the total number of morbid conditions coexisting with end stage renal disease. The particular concurrent medical
diagnoses included in the total count were chosen based on the previous literature in this area and consultation with an attending physician at the renal centers involved in the current study. The following diagnoses were included in the total count: hypertension, congestive heart failure, diabetes mellitus, arteriosclerotic cardiovascular disease, chronic obstructive pulmonary disease, malignancy, liver disease, and systemic lupus erythematosus.

**Criterion variable.** The criterion variable in this study was survival. Dialysis patients who died between January 1982 until June 1986 comprised the "deceased" group and those still alive in June 1986 comprised the "survivors" group.

**Procedure**

The procedure involved a review of the medical records of all patients who were on dialysis between January 1982 and December 1982. All subjects who met subject selection criteria described earlier were included as subjects in the current study. Once these patients were identified, information on the predictor and criterion variables was abstracted from their medical records.

The physiological measures of dietary compliance, BUN, IWG, and SP, were abstracted for all patients for the one year period between January and December 1982.
The two biochemical measures, BUN and SP, were taken monthly by medical staff at unannounced times. IWG was measured prior to each dialysis session. To match the three compliance parameters on time of measurement, IWG was measured by taking the values from the same weeks during which the biochemical measures were taken each month. The mean values across the one year period was calculated for each of the three variables for use in the statistical analyses of this study.

Measurements taken while a patient was hospitalized were not included as data in the current study. This controlled for other factors not related to noncompliance with diet such as surgery, infection, or bleeding which may have resulted in elevations on the physiological parameters of concern.

Analyses

Form of data. Two demographic predictor variables, race and sex, and the criterion variable, were measured on nominal scales. These variables, therefore, were dummy-coded for use in the analyses. Specifically, for the criterion variable, survivors were coded as 0 and deceased were coded as 1. The remainder of the predictor variables were measured on interval or ratio scales and were, therefore, included in the analyses in their raw form. The units of measurement were milligrams per deciliter for BUN, milliequivalents per liter for SP, and
kilograms for IWG.

**Preliminary descriptive statistics.** Descriptive statistics were performed on the data to describe the current sample. These statistics include measures of central tendency, standard deviations, and number of subjects. This information is provided on all variables for the total sample and for the two criterion groups, survivors and deceased.

**Correlational Procedures.** According to Prediction 1, it was hypothesized that if the measures of dietary compliance are important in survival, these measures should be correlated at least moderately and significantly with the criterion variable, survival group. Furthermore, these physiological parameters should be differentially correlated with group. This prediction was tested by examining the partial correlation matrix produced from the zero-order correlation matrix. With this matrix, the unique relation between each compliance variable and the criterion variable was examined after the effects of the other compliance parameters and additional predictor variables were removed or adjusted. Furthermore, the size, direction, and statistical significance levels of these correlations were examined to evaluate their differential relations to the criterion.

**Discriminant function analyses.** Predictions 2 and 3
were tested using two-group discriminant function analysis procedures. These procedures involved the determination of the best linear combination of predictor variables, i.e., discriminant function, which maximizes differences between criterion groups. Once the discriminant function was computed, it was employed to predict group membership. The accuracy of the predictions of group membership was tested by comparing the number of cases correctly classified using the discriminant function to the number expected to be classified correctly by chance.

According to Prediction 2, given the physiological measures of dietary compliance are important in survival, these variables should significantly add to the discrimination of criterion groups relative to the demographic/medical variables and collectively these predictors should discriminate groups at better than chance levels. These predictions were tested using a hierarchical discriminant function analysis. With this procedure, individual predictor variables or sets of variables were entered into the analysis in a priority order. For this analysis, the demographic/medical variables were entered first and then the compliance variables were included to determine the predictive power gained by adding the compliance variables to the demographic/medical variables. Within each set of
variables, a stepwise method of entry was employed. If a variable did not meet the minimal tolerance criterion, it was not included in the prediction equation.

The validity of the derived discriminant function was tested with a holdout sample (e.g., Hair, Anderson, Tatham, & Grablo'sky, 1979). Furthermore, external generalization is enhanced if the function is employed to classify a separate sample from that upon which it was developed. The total sample was equally divided into two samples, an analysis sample and a holdout sample to test the discriminant function and control for shrinkage. Chance probability levels were set at prior probability levels (i.e., the percent of subjects in each group).

Prediction 3 stated that given measures of dietary compliance are important in the prediction of mortality in hemodialysis patients, they collectively should discriminate between survivors and deceased patients at better than chance levels and these physiological parameters should discriminate differentially between groups. These predictions were tested using a stepwise discriminant function analysis. With this method, each of the three variables were entered based on the significance of their partial F values. If a variable did not meet the minimal tolerance criterion, it was not included in the equation. This analysis calculated the prediction equation which most parsimoniously predicts...
mortality based only upon the important dietary compliance variables which may facilitate clinical intervention. The validity of this discriminant function was tested with a holdout sample to increase external generalization. Chance probability levels were set at prior probability levels.
Results

Unit of Measurement

A one year mean of each of the three dietary compliance variables was proposed as the unit of measurement in this study based on the results of a pilot study. Practical constraints and methodological concerns, however, necessitate modification of the use of a one year mean across 12 data points. The major concern was that if a one year mean across 12 data points was required for a subject to be included in the analyses, a large number of patients (i.e., up to 60%), particularly deceased subjects, would be lost from the sample because of missing data for reasons such as absences from clinic, hospitalizations or death. As a result of this concern, a mean was taken across all available data points for subjects who had at least six monthly data points for the year for each dietary variable.

Prediction 1

According to Prediction 1, it was hypothesized that if the measures of dietary compliance are important in survival, they should be correlated at least moderately and significantly with the criterion variable, group (deceased vs survivors). Furthermore, they should be differentially correlated with group. The results of the partial correlations between each compliance variable and
the criterion variable after the effects of all other predictor variables were removed indicated low nonsignificant partial correlations for all three dietary variables. The correlations between the criterion variable and the dietary variables were .14 for BUN, -.14 for SP, and .06 for IWG. Furthermore, BUN and IWG correlated positively with group while SP correlated negatively with group. The results of these analyses indicated that Prediction 1 is only partially supported. That is, the dietary compliance variables are differentially related to the criterion variable when other predictors are removed. The partial correlations, however, are low and nonsignificant, therefore, failing to completely support Prediction 1.

In addition to calculating the partial correlations between criterion group and the dietary compliance variables for the mean across all data points for patients who had data for at least six months, partial correlations were calculated for each single monthly data point with the criterion. The purpose of these additional analyses was to allow for comparison of the current results with those of previous studies which employed a single data point for analyses, and to investigate the specific differences obtained when one versus the average of multiple data points are employed.

The partial correlations between criterion group and
single monthly measures of BUN after all other predictors were removed indicated correlations which ranged from -.07 to .39, and significance levels which ranged from nonsignificant to .002. The results for SP indicated correlations which ranged from -.27 to .08, and significance levels which ranged from nonsignificant to .03. The results for IWG also indicated correlations which ranged from -.16 to .23, and significance levels which ranged from nonsignificant to .05. These results indicate that there is much variability in the dietary compliance measures from month to month and the use of a single data point for analyses with this sample would result in unreliable findings.

**Prediction 2**

According to Prediction 2, given that physiological measures of dietary compliance are important in predicting survival group, these variables would add significantly to the discrimination of group relative to the demographic/medical variables. Furthermore, the combination of these variables would discriminate criterion group at better than chance levels. These predictions were tested using a hierarchical discriminant function analysis. For this analysis, the demographic/medical variables were entered first and then the dietary variables were included to determine the predictive power gained by adding the dietary compliance
variables to the demographic/medical variables. Within each set of variables, a stepwise method of entry was employed which included only those variables from each entry level which significantly added to the prediction of the criterion.

The results of this analysis (N = 35 in analysis sample) indicated that only two demographic/medical variables, current age and age at onset of hemodialysis, were included in the discriminant function and the resulting discriminant function was nonsignificant \([x^2(2) = 4.1595, \text{ N.S.}]\). The canonical correlation between the predictor variables and the criterion was .35 which accounted for 12% of the variance (Lambda = .88). The classification sample for the analysis sample consisted of 18 survivors and 34 deceased subjects, yielding a proportional chance criterion of 54.50% (Tabachnik & Fidel, p. 102). The overall classification accuracy for the analysis sample was 63.46% which is 16% better than achieved by chance alone (See Table 8). The suggested criteria for achieving significant classification accuracy is 25% greater overall accuracy than classification accuracy achieved by chance (Tabachnik & Fidel, p. 103). Therefore, although classification accuracy is better than chance accuracy, these results are not significantly different statistically from chance. It is also noteworthy that a larger proportion
of deceased subjects (82.4%) were classified correctly than were survivors (27.8%).

The cross-validation sample consisted of 22 survivors and 36 deceased subjects, yielding a proportional chance criterion of 52.88%. The overall classification accuracy for this sample was 63.79% which is 21% greater than chance (See Table 8). Again, a larger proportion of deceased subjects (80.6%) were correctly classified compared with survivors (36.4%).

Given that the sample included in the development of the discriminant function was relatively small and the obtained function was not significant, a second hierarchical stepwise discriminant function analysis was conducted. This analysis also entered the demographic/medical variables first and then entered the dietary variables. This analysis, however, included the entire sample (N = 69) in the determination of the discriminant function. The results of this analysis indicated that the same two variables, current age and age at onset, were included in the discriminant function. Again, no dietary variables were included in the function.

The resulting discriminant function was marginally significant \( \chi^2(2) = 5.50, p < .07 \). The canonical correlation between predictor variables and the criterion was .28 which accounts for 8% of the variance (\( \Lambda = .92 \)). The classification sample consisted of 40
survivors and 70 deceased subjects, yielding a proportional chance criterion of 53.92%. The overall classification accuracy for this sample was 60.91% which is 13% better than classification accuracy achieved by chance (See Table 9). Furthermore, this discriminant function resulted in the correct classification of a larger proportion of deceased subjects (67.10%) than survivors (50.00%). Given that the results of this analysis were similar to the results of the analysis that included the cross-validation sample, support is garnered for the stability of the obtained discriminant function.

Given that the dietary compliance variables did not even meet the minimum criteria necessary for entrance in the discriminant function, these results suggest that the dietary variables play a limited role in the prediction of the criterion in comparison to demographic/medical variables.

Prediction 3

Prediction 3 stated that given measures of dietary compliance are important in the prediction of survival in hemodialysis patients, they collectively would discriminate between survivors and deceased patients at better than chance levels and these physiological parameters would discriminate differentially between groups. These predictions were tested using a stepwise discriminant function analysis using means across all
data points for subjects with physiological data for at least 6 months.

The results of this analysis (N = 36) indicated that only one dietary variable, IWG, met the inclusion criteria and was included in the discriminant function. The resulting discriminant function was nonsignificant \([x^2(1) = 1.11, \text{ N.S.}]\). The canonical correlation between the predictor variable and the criterion was .18 which accounts for 3% of the variance (\(\text{Lambda} = .97\)). The classification sample for the analysis consisted of 22 survivors and 36 deceased subjects, yielding a proportional chance criterion of 52.88%. The overall classification accuracy for the analysis sample was 67.24% which is over 25% better than chance classification accuracy (See Table 10). This function resulted in better accuracy for predicting group for deceased (86.1%) subjects compared to survivors (36.4%).

The cross-validation sample consisted of 18 survivors and 34 deceased subjects, yielding a proportional chance criterion of 54.50%. The overall classification accuracy for the cross-validation sample was 67.31 which exceeds 25% greater than chance classification accuracy (See Table 10). These results indicated that deceased subjects (85.3%) were classified correctly more frequently than survivors (33.3%).

Given the small sample size for the analysis and
the lack of power, the above analysis was repeated with
the inclusion of all eligible subjects in the analysis
sample and the exclusion of a cross-validation sample.
This analysis included 71 subjects in the determination
of the discriminant function. The results of this
analysis were similar to the results obtained with the
split-sample, therefore, providing support for the the
obtained function. Again, only IWG was included in the
discriminant function and the resulting function was
nonsignificant \( \chi^2(1) = 1.3680, \text{ N.S.} \). The canonical
correlation between the predictor and the criterion was
.14 which accounted for 2% of the variance (Lambda = .98). The pattern of classification results from this
analysis closely paralleled those previously obtained
(See Table 11). The classification sample consisted of
40 survivors and 70 deceased subjects, yielding a
proportional chance criterion of 53.92%. The overall
classification accuracy obtained was 64.55% which was 20%
greater than chance.

In addition to calculating the stepwise discriminant
analyses for the dietary variables, further analyses were
conducted to determine the results that would be obtained
if all dietary variables were forced into the equation
using a direct discriminant analysis approach. The
resulting discriminant function was nonsignificant \( \chi^2(3) = 1.2284, \text{ N.S.} \). The canonical correlation between the
predictor variables and the criterion variable was .20 which accounted for 4% of the variance (Lambda=.96). The classification sample for the analysis sample consisted of 18 survivors and 34 deceased subjects, yielding a proportional chance criterion of 54.50%. The overall classification accuracy for the analysis sample was 69.23 which is significantly (27%) greater than accuracy obtained by chance (See Table 1). For this sample, 11.1% of survivors were accurately classified compared to 100% of deceased patients.

The cross-validation sample consisted of 22 survivors and 36 deceased subjects, yielding a proportional chance criterion of 52.88% (See Table 12). The overall classification accuracy for this sample was 65.52% which is 24% better than chance accuracy indicating marginally significant prediction accuracy. Again, prediction accuracy for deceased subjects (94.4%) was much better than for survivors (18.2%).

The results of these analyses offer little support for dietary variables as meaningful predictors of survival in hemodialysis patients. The current results suggested that dietary compliance variables by themselves have a limited role in the prediction of survival of hemodialysis patients and offer little to the prediction of survival after demographic and medical history variables have been included.
Further Analyses

In addition to the above proposed analyses employing a categorical criterion variable, deceased versus survivor, further analyses were conducted using the number of months a patient survived on dialysis as the criterion variable. Employing an interval variable, number of months survived on dialysis, would permit the use of a second method of addressing the same proposed research questions. That is, regression analyses could be employed with the same predictor variables with months survived as the criterion variable. The results of such analyses would help to elucidate the role that dietary variables play in survival of hemodialysis patients.

A series of multiple regression analyses were conducted including only deceased subjects \((N = 70)\) to determine the amount of variance accounted for by the predictor variables. Direct multiple regression analyses were conducted for the two subsets of predictors to determine how well each could predict length of survival on dialysis. The results of the regression analysis including only the demographic/medical variables indicated a significant regression equation \([F(5, 64) = 12.11, p < .0001]\) which accounted for 45% of the variance in length of survival. The results of the analysis including only the dietary variables indicated a nonsignificant regression equation \([F(3, 66) = 0.53, \text{ N.S.}]\)
which accounted for only 2% of the variance in survival length.

To obtain the set of predictors which most parsimoniously predicted survival, stepwise multiple regression analyses were employed for the deceased subsample. First, the demographic/medical variables were entered into a stepwise regression analysis and the results indicated a significant regression equation \([F(2,67) =28.27, p < .0001]\) which accounted for 44% of the variance in length of survival on dialysis. This regression equation included two predictor variables, age at onset of dialysis and age at time of study (See Table 13). Onset age accounted for 14% of the variance and age at time of study accounted for an additional 30% of the variance in survival length.

Another stepwise multiple regression analysis was conducted which included both demographic/medical variables and dietary variables. The goal of this analysis was to determine the best set of predictors and to determine if dietary variables add to the prediction of survival above that obtained with just the demographic/medical variables. The results of this analysis were identical to those obtained when just the demographic/medical variables were included as predictors. The dietary variables, therefore, offer little to the prediction of length of survival on
dialysis after important demographic/medical variables have been included as predictors.

The same series of analyses were conducted on the full sample of subjects including both deceased and survivors (N = 110). Length of survival for deceased subjects was the number of months from the time of initiation of dialysis until the time of death. Length of survival for the survivors was the number of months from the initiation of dialysis until the time of the current study. The same pattern of results was obtained for the entire sample as was obtained for analyses including only the deceased subjects. That is, the direct regression including only the demographic/medical variables indicated a significant equation \[ F(5,104) = 15.08, p < .00001 \] which accounted for 39% of the variance in survival. The direct regression including the dietary variables indicated nonsignificant results \[ F(3,106) = 0.72, \text{N.S.} \] and these predictors accounted for less than 1% of the variance in length of survival.

The stepwise multiple regression analysis including only the demographic/medical variables indicated significant results \[ F(2,107) = 36.02, p < .00001 \]. Two predictors were included in this equation, age at onset of dialysis which accounted for 13% of the variance and age at time of study which accounted for 39% of the variance in length of survival. The stepwise regression
analysis which included both demographic/medical predictors and dietary predictors indicated the same results as the analysis including only demographic/medical variables. Again, the dietary variables failed to add to the prediction of survival beyond that achieved by the demographic/medical variables.
Discussion

The goal of the current study was to gain knowledge of the role that dietary compliance plays in the survival of end-stage renal failure patients receiving chronic in-center hemodialysis. The present study investigated the relation of the three most commonly employed physiological parameters of dietary compliance to survival in hemodialysis and how well these dietary variables independently and relative to demographic/medical history variables predict survival in these patients. In general, the results of this investigation suggest that dietary compliance variables as measured in this study play a minimal role in survival of end-stage hemodialysis patients. Furthermore, in support of previous literature, demographic/medical history variables are good predictors of survival in hemodialysis patients and dietary measures offer little in predicting survival after demographic and medical history information is considered. The current results also support a previous finding which suggests that multiple measures of dietary variables should be employed instead of single data points when conducting this type of research.

The results of analyses addressing the relation between the dietary variables and survival suggest that
the three commonly used physiological measures of dietary compliance (i.e., BUN, SP, IWG) in dialysis patients have little relation to whether a patient will be living or deceased four years later. Given diet has traditionally been considered a very important component of the treatment regimen for dialysis patients, these results indicate the need for much further research in this area. Further research is needed on the reliability and validity of measures of dietary compliance and the role that diet plays in the health of dialysis patients. Before researchers and health care professionals proceed further with assessing compliance and developing interventions for dietary noncompliance in hemodialysis patients, they need to acquire a much better understanding of the nature of these dietary parameters (e.g., stability) and how they relate to dietary intake and associated medical parameters.

The current study provided a preliminary step in understanding the reliability and validity of physiological measures of dietary compliance. The findings of the current study indicated that the partial correlations between each of the three dietary variables with group (survivor versus deceased) after all other variables were removed were low. In addition to employing the mean across multiple months and since most previous studies in this area employed a single data point as the
unit of measurement, partial correlations were also computed using single month data points. The partial correlations for single data points indicated that these dietary variables demonstrated much variability across time. That is, if a single month would be chosen as the unit of measurement for dietary compliance, very different results would be obtained dependent upon the particular month chosen. These findings provide strong support for taking multiple measurements across time when studying these dietary compliance variables in order to obtain a more representative index of these variables. The findings of the current study and the concerns about the reliability of the dietary measures employed cast doubt on the findings of most of the previous research in this area, given most researchers employed a single data point as their unit of measurement. It would be important to replicate previous studies in this area with the inclusion of multiple data points and improved methodologies before their conclusions can be accepted with confidence.

The results of the discriminant function analyses further support the finding that the dietary compliance variables play a minor role in the prediction of survival in end-stage hemodialysis patients. When demographic/medical history variables were evaluated as predictors of survival, the current findings indicated
that only two of these variables were statistically important. These two variables were the patients' age at the time of study and the age at which chronic dialysis treatments were initiated. Furthermore, the results of the current study indicate that much more accurate results were obtained in the classification of deceased patients relative to that of surviving patients. That is, when employing the prediction equations obtained in this study, more confidence could be placed in predicting that a patient was going to be deceased in four years than in a prediction that the patient would be alive.

The current results are consistent with previous studies which investigated the influence of demographic and medical history variables on the survival of hemodialysis patients. Specifically, in corroboration with the hypotheses of previous studies (e.g., Hellerstedt, 1984; Guttman, 1983), two demographic and medical history variables contributed the most to the prediction of survival in hemodialysis patients. When the dietary compliance variables were included along with the demographic and medical history variables as predictors of survival, they did not even meet the minimal criteria necessary to be included in the prediction equation once the other set of variables was included. In addition, when the three dietary variables were considered as predictors of survival independent of
the demographic/medical variables, they were found to account for a very small proportion of the variance in the prediction of surviving versus deceased patients.

In addition to investigating how well demographic/medical history and dietary variables predicted whether a patient would be alive or deceased after four years, the current study evaluated the ability of these variables to predict the length of time a person would survive on hemodialysis from the onset of chronic dialysis. These findings corroborated the findings on the prediction of whether a patient was surviving or deceased after four years and indicated that the demographic/medical variables accounted for a large proportion of the variance in length of survival while the dietary variables contributed little to this prediction. The best predictors of length of survival were the same two demographic/medical variables, current age and age at initiation of dialysis. Specifically, the current findings indicated that increased length of survival is negatively related to age of onset and current age. That is, the younger a person was at the initiation of chronic dialysis and the younger his or her current age, the longer the expected survival on hemodialysis. This finding supports the conclusion of Hellerstedt et al. (1984) that irrespective of renal disease, mortality increases with advancing age and the
proportion of ESRD patients who die within five years after the onset of the disease increases disproportionately with advancing age.

Given the minor role that dietary compliance variables appear to play in survival, the necessity for strict dietary recommendations for chronic hemodialysis patients seems questionable. As highlighted in the Introduction, research has indicated that dietary modification may slow the progression of renal failure early in the disease process. The findings of the current investigation, however, suggest that diet may not be as important in the health of end-stage renal failure patients on chronic hemodialysis as it may be for patients early in the disease process. Although it is premature to make changes in clinical practice based on the results of a single study, pending further research, a number of clinical implications may be entertained based upon the current findings.

Although it would be pointless to suggest that dietary recommendations for end-stage renal failure be completely eliminated, it may be worthwhile to consider relaxing these recommendations. For example, instead of imposing strict recommendations for specific daily intake of the various elements of the renal diet, patients may be educated in how these dietary elements are related to acute medical complications. Examples of the type of
information that might be useful to patients would be the relation between fluid intake and edema and the relation between potassium intake and cardiac arrhythmias. Furthermore, it may be important to educate patients about the minimal level of intake of various dietary elements they may consume, above which they may reach potentially dangerous levels. Relaxing the dietary recommendations within known medical constraints would provide a balance between medical necessity and improved quality of life for end-stage renal failure patients.

In addition to the above mentioned suggestions about patient education on dietary compliance, an important recommendation concerning the assessment and management of dietary compliance may be provided. Given that the physiological parameters of dietary compliance demonstrate much variability from month to month and from parameter to parameter, health care professionals should consider a patient's pattern of compliance across different dietary measures and across multiple data points when assessing dietary compliance and when planning dietary interventions. It is especially important to avoid making decisions about medical or dietary management of hemodialysis patients based on isolated measures of dietary indices.

The methodology of the current study was developed in an attempt to overcome most of the shortcomings of
previous research in this area (e.g., small and/or heterogeneous samples; single measurements of the dietary variables). Although most of these methodological goals were achieved, several potential shortcomings of this project should be elucidated to facilitate replication of this type of study with further improved methodology. Due to practical constraints, the size of the sample of eligible patients was somewhat smaller than anticipated. This was due to a significant proportion of missing data most likely related to characteristics of the population and the nature of the construct under investigation. For example, hemodialysis patients are likely to have missing data due to hospitalizations or absences from clinic during the study period. Therefore, before incorporating changes in the dietary management of hemodialysis patients based on these results, it would be important to replicate the current study employing a larger number of subjects. Furthermore, given the current study was conducted in dialysis centers in a southern city, the ethnic, racial, and cultural subsamples and their dietary habits may not be representative of clinics in other areas of the country or a national sample. It would be worthwhile to replicate this study with different clinics in different areas of the country to gain a more representative sample of the national population of hemodialysis patients.
In summary, the findings of the current study suggest that the three dietary variables studied offer little to the prediction of survival on hemodialysis after the effects of important demographic/medical variables have been considered. Furthermore, even when considered independently, dietary variables play a minor role in the prediction of survival on dialysis. Two demographic/medical history variables, age and age at onset of chronic dialysis, have consistently been found to be good predictors of survival. These variables, in contrast to dietary variables, are fixed and cannot be manipulated by health care professionals. Although health care professionals have the potential to intervene in the dietary management of chronic hemodialysis patients, the current study failed to provide support for the validity of dietary compliance as measured in the current study as predictive of survival. It is important to reiterate, however, that the current findings should be conservatively interpreted pending further research on the reliability and validity of the employed measures of dietary compliance.
References


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Caron, H.S., & Roth, H.P. (1968). Patients' cooperation with medical regimen: Difficulties in identifying the


failure and their treatment (pp.53-70). New York: Plenum Publishing Co.


Appendix A

Compliance Criteria

1. Excellent. Weight gain between dialysis is never above 500g. Predialysis serum potassium levels are never above 6 mEq/liter and most of the time less. Predialysis BUN levels are steady.

2. Good. Weight gain between dialyses is from 500 to 1000 g. Predialysis potassium levels are usually 6 mEq/liter. Perdialysis BUN levels are usually steady but may show occasional jumps.

3. Fair. Weight gain between dialyses is mostly 1000 to 1500 g rarely going up to 2000 g. Predialysis potassium levels are from 6.0 to 6.8 mEq/liter.

4. Some abuse. Weight gain between dialysis is always above 2000 g or most of the time above 2500 g. Predialysis potassium levels are frequently above 7.0 mEq/liter.

5. Great abuse. Weight gain between dialyses is always above 2000 g or most of the time above 2500 g. Predialysis potassium levels are frequently above 7.0 mEq/liter.

Appendix B

Relevant Portions of the Renal Diet

Potassium is a mineral found inside the cells of the body. It is important for normal muscle function and nerve stimulation. If potassium builds up to high levels in the blood, it can interfere with the normal rhythm of the heart and can eventually lead to cardiac arrest. Potassium is found in nearly all foods; therefore, it is important to eat only the recommended foods and only the amounts shown on your meal plan.

The following foods should be avoided:

<table>
<thead>
<tr>
<th>Meat</th>
<th>Fruits and Vegetables</th>
<th>Breads and Cereals</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Meat</td>
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<tr>
<td></td>
<td>Brains</td>
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<td></td>
<td>Kidneys</td>
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<tr>
<td></td>
<td>Goose</td>
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<tr>
<td></td>
<td>Fruits and Vegetables</td>
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<tr>
<td></td>
<td>Tamarinds</td>
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<td></td>
<td>Chard</td>
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<tr>
<td></td>
<td>Dried Beans and peas</td>
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<td></td>
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<tr>
<td></td>
<td>Lima Beans, butter beans, blackeye peas, field peas</td>
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<tr>
<td></td>
<td>Garbanzo</td>
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<td></td>
<td>Lentils</td>
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<td></td>
<td>Parsnips</td>
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<td></td>
<td>Pumpkin</td>
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<td></td>
<td>Spinach</td>
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<tr>
<td></td>
<td>Succotash</td>
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<tr>
<td></td>
<td>Oranges</td>
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<tr>
<td></td>
<td>Orange juice</td>
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<tr>
<td></td>
<td>Bran Cereals</td>
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<tr>
<td></td>
<td>Other</td>
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<tr>
<td></td>
<td>Low Sodium Baking Powder</td>
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<td></td>
<td>Coconut</td>
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<td></td>
<td>Nuts</td>
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<td>Salt Substitutes</td>
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<td></td>
<td>Molasses</td>
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<td>Brown Sugar</td>
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Appendix C

Relevant Portions of the Renal Diet

Fluid restrictions vary according to urinary output. Excessive fluid intake can cause edema (a swelling of face, hands, feet, legs and eventually the entire body), high blood pressure and congestive heart failure. A fluid weight gain of 1 to 2 kilos between dialysis is desirable. A large fluid gain can cause nausea and cramping. Anything that pours or melts is considered fluid.

If your weight gain is always higher than it should be, one of the following is happening:

(1) Your sodium intake is too high,
(2) Your fluid intake is too high, or
(3) Your sodium and fluid intake are both too high.

It takes 2 cups of fluid to gain each pound of weight.

The following foods are considered fluid:

Water
Ice
Coffee
Tea
Carbonated beverages
Fruit juices
Lemonade
Kool-Aid
Alcoholic beverages
Gravy
Salad Dressing
Soups

Milk
Cream
Ice Cream
Gelatin
Sherbet
Popsicle
Pudding
 Custard
Cream pie filling
Syrup
Sauces
Juicy foods which include fresh fruits and vegetables (watermelon, tomatoes, peaches, etc.)
Potlicker from cooked greens or cabbage, etc.

Protein is a nutrient that is essential for growth, muscle building and repair of body tissue. Protein intake is usually limited in chronic renal failure. When kidneys do not function properly, end products build up in the blood stream. These end products are poisonous to the body and can cause nausea, vomiting and fatigue. The best sources of protein are animal sources.

These are:

EGGS
MILK
MEAT
POULTRY
FISH and SHELLFISH
Appendix D

DIET RESTRICTION OF
PROTEIN, SODIUM, POTASSIUM AND FLUID

NAME: ____________________________

DIET PRESCRIPTION:

__________ Grams Protein
__________ Milligrams Sodium
__________ Milligrams Potassium
__________ cc Fluid (____ Cups)

DIETITIAN: ____________________________

DATE: ____________________________

PHONE NUMBER ____________________________
Table 1
Comparisons of Compliance Studies in Dialysis

<table>
<thead>
<tr>
<th>Studies</th>
<th>Potassium</th>
<th>Phosphorus</th>
<th>BUN</th>
<th>Wt. Gain</th>
<th>Other</th>
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</thead>
<tbody>
<tr>
<td>Armstrong et al., 1983; N=127</td>
<td>X of 5 slopes</td>
<td>X of 5 slopes</td>
<td>X of 5 slopes</td>
<td>X of 5 slopes</td>
<td>staff ratings - undefined</td>
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<tr>
<td>Barnes, 1976; N=1</td>
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<td>&lt;.9 kg</td>
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<tr>
<td>Basta, 1981 3.5-5.0 mEq/L N=60</td>
<td>&lt;100 mg%</td>
<td>(Q 200 mg%)</td>
<td>≤1.5 kg/24h</td>
<td>≥1.6 kg/24h</td>
<td>physical symptoms (e.g., respiratory distress); BP; attendance</td>
</tr>
<tr>
<td>Blackburn, 1977; N=53</td>
<td>3.5-5.0 mEq/L</td>
<td>3.5-5.0 mg/dl</td>
<td>&lt;1.8 kg</td>
<td></td>
<td>Subjective staff ratings</td>
</tr>
<tr>
<td>Bollin et al., 1982; N=30</td>
<td>Six month point system</td>
<td>≥4 points</td>
<td>X of 500cc over prescribed fluid intake</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 1 (Continued)

<table>
<thead>
<tr>
<th>Studies</th>
<th>Potassium</th>
<th>Phosphorus</th>
<th>BUN</th>
<th>Wt. Gain</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheek, 1982; N=27</td>
<td>3.5-5.0 mEq/L</td>
<td>0-4.5 mg</td>
<td></td>
<td>0-1.5 kg</td>
<td></td>
</tr>
<tr>
<td>Cummings et al., 1981; N=116</td>
<td>&lt;5.5 mEq/L</td>
<td></td>
<td></td>
<td>&lt;3.0 kg</td>
<td></td>
</tr>
<tr>
<td>Cummings, et al., 1982; N=120</td>
<td>&lt;5.5 mEq/L</td>
<td>&lt;5.5 mg</td>
<td></td>
<td>&lt;3.0 kg</td>
<td>7-point self-report scale for each task</td>
</tr>
<tr>
<td>Cummings et al., 1984; N=116</td>
<td>Not defined</td>
<td>Not defined</td>
<td></td>
<td>Not defined</td>
<td>7-point subjective ratings by staff and patients</td>
</tr>
<tr>
<td>Finn et al., 1985; N=4</td>
<td>&lt;5.5 mEq/L</td>
<td></td>
<td></td>
<td>&lt;45 kg</td>
<td></td>
</tr>
<tr>
<td>Hart, 1979; N=10</td>
<td>≤5.0 mEq/L</td>
<td></td>
<td></td>
<td>&lt;5% of dry weight</td>
<td></td>
</tr>
<tr>
<td>Hartman, et al., 1978; N=50</td>
<td>Not defined</td>
<td>Not defined</td>
<td></td>
<td>Not defined</td>
<td>7-point subjective rating by researcher</td>
</tr>
<tr>
<td>Studies</td>
<td>Potassium</td>
<td>Phosphorus</td>
<td>BUN</td>
<td>Wt. Gain</td>
<td>Other</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------</td>
<td>-----------------</td>
<td>----------------</td>
<td>------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Kaplan De-Nour et al., 1972; N=43</td>
<td>1-5 scale staff rating from physio data</td>
<td>1-5 scale staff rating from physio data</td>
<td>1-5 scale staff rating from physio data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kaplan De-Nour et al., 1976; N=136</td>
<td>1-3 scale staff rating from physio data</td>
<td>1-3 scale staff rating from physio data</td>
<td>1-3 scale staff rating from physio data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kirilloff, 1981; N=31</td>
<td>Not defined</td>
<td>Not defined</td>
<td>Not defined</td>
<td>Creatinine Used but not defined</td>
<td></td>
</tr>
<tr>
<td>Keane, et al., 1981; N=2</td>
<td>&lt;1.5-2.5(Case1)</td>
<td></td>
<td>&lt;3.0-3.5(Case2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prococi, 1978; N=31</td>
<td>≤5.5 mEq/L</td>
<td></td>
<td>≤.9 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prococi, 1981; N=31</td>
<td>≤6.0 mEq/L</td>
<td></td>
<td>≤1.4 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schlebusch et al., 1982; N=25</td>
<td></td>
<td></td>
<td></td>
<td>&quot;Diet&quot; and &quot;medication&quot; used but not defined</td>
<td></td>
</tr>
<tr>
<td>Studies</td>
<td>Potassium</td>
<td>Phosphorus</td>
<td>BUN</td>
<td>Wt. Gain</td>
<td>Other</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------</td>
<td>------------</td>
<td>---------</td>
<td>----------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>Seime, 1980; 1-3 scale 1-3 scale</td>
<td>1-3 scale</td>
<td>1-3 scale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N=3 from Kaplan De-Nour et al., 1976</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sherwood, 1983; N=119</td>
<td>Not defined</td>
<td>Not defined</td>
<td></td>
<td>Not defined</td>
<td>5- or 7-point scale by patients; &quot;overall compliance index&quot;</td>
</tr>
<tr>
<td>Streltzer, 1983; N=46</td>
<td>&lt; 2 kg</td>
<td>(2.5 kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yanagida, et al., 1981; N=46</td>
<td>0-2.0 kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yanitski, 1983; N=29</td>
<td>0-5.5 Mol/L</td>
<td>0-1.6 Mol/L</td>
<td></td>
<td>0-0.5 kg/24 hr</td>
<td></td>
</tr>
</tbody>
</table>

**Note.** Values or ranges presented are those for compliance; noncompliance criteria are presented in some cases in parentheses when provided by the authors.
### Table 2: Pearson Correlations Among the Study’s Measures of Compliance

<table>
<thead>
<tr>
<th></th>
<th>Phosphate-Binding Medicine</th>
<th>Diet</th>
<th>Fluid Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphate-binding medicine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-Report</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nurse rating</td>
<td>0.28</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Serum phosphorus</td>
<td>0.36</td>
<td>0.36</td>
<td>1.00</td>
</tr>
<tr>
<td>Diet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-report</td>
<td>0.30</td>
<td>0.30</td>
<td>0.08</td>
</tr>
<tr>
<td>Nurse rating</td>
<td>0.22</td>
<td>0.21</td>
<td>0.10</td>
</tr>
<tr>
<td>Serum potassium</td>
<td>0.10</td>
<td>0.21</td>
<td>0.10</td>
</tr>
<tr>
<td>Fluid limit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-report</td>
<td>0.29</td>
<td>0.13</td>
<td>0.19</td>
</tr>
<tr>
<td>Nurse rating</td>
<td>0.19</td>
<td>0.73</td>
<td>0.25</td>
</tr>
<tr>
<td>Weight gain</td>
<td>0.07</td>
<td>0.29</td>
<td>0.17</td>
</tr>
</tbody>
</table>
Table 3

Re-Constructed MIMM Matrix

<table>
<thead>
<tr>
<th></th>
<th>Self-Report</th>
<th>Nurse Ratings</th>
<th>Physiological</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Phos</td>
<td>IWG</td>
<td>SP</td>
</tr>
<tr>
<td><strong>Self-Report</strong></td>
<td>Phos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phos</td>
<td>(1.00)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IWG</td>
<td>.30</td>
<td>.30</td>
<td>.13</td>
</tr>
<tr>
<td>SP</td>
<td>.29</td>
<td>.27</td>
<td>(1.00)</td>
</tr>
<tr>
<td><strong>Nurse Ratings</strong></td>
<td>Phos</td>
<td>.28</td>
<td>.30</td>
</tr>
<tr>
<td>IWG</td>
<td>.22</td>
<td>.36</td>
<td>.26</td>
</tr>
<tr>
<td>SP</td>
<td>.19</td>
<td>.34</td>
<td>.21</td>
</tr>
<tr>
<td><strong>Physiological</strong></td>
<td>Phos</td>
<td>.36</td>
<td>.08</td>
</tr>
<tr>
<td>IWG</td>
<td>.10</td>
<td>.19</td>
<td>.04</td>
</tr>
<tr>
<td>SP</td>
<td>.07</td>
<td>.24</td>
<td>.04</td>
</tr>
</tbody>
</table>

Note. Phos = Phosphate-binding medicine; IWG = Fluid limit; SP = Diet; and Physiological = Serum Phosphorus, Serum Potassium, and Weight Gain.
Table 4
Bivariate Correlations for 3-month, 6-month, and 1-year Means for IWG, BUN, and SP

<table>
<thead>
<tr>
<th>Parameter</th>
<th>3-month</th>
<th>6-month</th>
<th>1-year</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$r$</td>
<td>.07 - .61</td>
<td>.74</td>
<td>.67</td>
</tr>
<tr>
<td>$p&lt;\alpha$</td>
<td>(NS - .0005)</td>
<td>(.0005)</td>
<td>(.0005)</td>
</tr>
<tr>
<td>BUN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$r$</td>
<td>.61 - .73</td>
<td>.77</td>
<td>.67</td>
</tr>
<tr>
<td>$p&lt;\alpha$</td>
<td>(.0005)</td>
<td>(.0605)</td>
<td>(.0005)</td>
</tr>
<tr>
<td>IWG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$r$</td>
<td>.06 - .33</td>
<td>.18</td>
<td>.46</td>
</tr>
<tr>
<td>$p&lt;\alpha$</td>
<td>(NS - .02)</td>
<td>(NS)</td>
<td>(.05)</td>
</tr>
</tbody>
</table>

Note. All correlations involve at least 50 subjects.
Table 5
Sample Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (Yr/Mos)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total (N=110)</td>
<td>52/9</td>
<td>14/9</td>
<td>20/6-78/1</td>
<td>53/3</td>
</tr>
<tr>
<td>Deceased (N=70)</td>
<td>55/3</td>
<td>13/5</td>
<td>20/6-78/1</td>
<td>56/4</td>
</tr>
<tr>
<td>Survivors (N=40)</td>
<td>48/5</td>
<td>16/1</td>
<td>23/2-75/11</td>
<td>51/0</td>
</tr>
<tr>
<td><strong>Onset Age (Yr/Mos)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>48/11</td>
<td>14/6</td>
<td>9/6-76/10</td>
<td>50/2</td>
</tr>
<tr>
<td>Deceased</td>
<td>50/8</td>
<td>14/3</td>
<td>9/6-76/10</td>
<td>51/7</td>
</tr>
<tr>
<td>Survivors</td>
<td>46/0</td>
<td>14/6</td>
<td>19/8-72/4</td>
<td>47/5</td>
</tr>
<tr>
<td><strong>Years on Dialysis (Yr/Mos)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3/11</td>
<td>3/2</td>
<td>0/10-18/1</td>
<td>3/0</td>
</tr>
<tr>
<td>Deceased</td>
<td>3/11</td>
<td>3/7</td>
<td>0/10-17/7</td>
<td>2/9</td>
</tr>
<tr>
<td>Survivors</td>
<td>3/11</td>
<td>3/2</td>
<td>0/10-18/1</td>
<td>3/4</td>
</tr>
<tr>
<td><strong>Survival on Dialysis (Yr/Mos)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>6/7</td>
<td>3/8</td>
<td>0/7-21/6</td>
<td>6/4</td>
</tr>
<tr>
<td>Deceased</td>
<td>5/4</td>
<td>3/7</td>
<td>0/7-21/6</td>
<td>4/10</td>
</tr>
<tr>
<td>Survivors</td>
<td>8/8</td>
<td>2/8</td>
<td>5/1-18/0</td>
<td>8/3</td>
</tr>
</tbody>
</table>

Note. Age = age at the time of the study. Survival = number of months on dialysis until death or the end of the study (1986).
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total</th>
<th>Deceased</th>
<th>Survivors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>57%</td>
<td>53%</td>
<td>64%</td>
</tr>
<tr>
<td>Female</td>
<td>43%</td>
<td>47%</td>
<td>36%</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>66%</td>
<td>60%</td>
<td>77%</td>
</tr>
<tr>
<td>White</td>
<td>34%</td>
<td>40%</td>
<td>23%</td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>10%</td>
<td>11%</td>
<td>8%</td>
</tr>
<tr>
<td>Married</td>
<td>64%</td>
<td>61%</td>
<td>68%</td>
</tr>
<tr>
<td>Divorced</td>
<td>11%</td>
<td>10%</td>
<td>13%</td>
</tr>
<tr>
<td>Separated</td>
<td>7%</td>
<td>9%</td>
<td>3%</td>
</tr>
<tr>
<td>Widowed</td>
<td>8%</td>
<td>9%</td>
<td>8%</td>
</tr>
</tbody>
</table>
Table 7

Number of Concurrent Diagnoses for Total Sample

<table>
<thead>
<tr>
<th>Number of Diagnoses</th>
<th>Percent of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>1</td>
<td>49</td>
</tr>
<tr>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 8
Hierarchical Stepwise for Demographic/Medical History Variables followed by Dietary Variables with a Holdout Sample

Analysis Sample Classification Results

<table>
<thead>
<tr>
<th>Actual Group</th>
<th>N</th>
<th>Survivors</th>
<th>Deceased</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survivors</td>
<td>18</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27.8%</td>
<td>72.2%</td>
</tr>
<tr>
<td>Deceased</td>
<td>34</td>
<td>6</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17.6%</td>
<td>82.4%</td>
</tr>
</tbody>
</table>

Overall Accuracy = 63.46%

Cross-Validation Sample Classification Results

<table>
<thead>
<tr>
<th>Actual Group</th>
<th>N</th>
<th>Survivors</th>
<th>Deceased</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survivors</td>
<td>22</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36.4%</td>
<td>63.6%</td>
</tr>
<tr>
<td>Deceased</td>
<td>36</td>
<td>7</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19.4%</td>
<td>80.6%</td>
</tr>
</tbody>
</table>

Overall Accuracy = 63.79%
Table 9
Hierarchical Stepwise Discriminant Function Analysis for Demographic/Medical History Variables followed by Dietary Variables without a Cross-Validation Sample

Classification Results

<table>
<thead>
<tr>
<th>Actual Group</th>
<th>N</th>
<th>Predicted Survivors</th>
<th>Predicted Deceased</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survivors</td>
<td>40</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50.0%</td>
<td>50.0%</td>
</tr>
<tr>
<td>Deceased</td>
<td>70</td>
<td>23</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32.9%</td>
<td>67.1%</td>
</tr>
</tbody>
</table>

Overall Accuracy = 60.91%
Table 10

Stepwise Discriminant Function Analysis for the Three Dietary Variables with a Holdout Sample

<table>
<thead>
<tr>
<th>Actual Group</th>
<th>N</th>
<th>Predicted</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Survivors</td>
<td>Deceased</td>
<td></td>
</tr>
<tr>
<td>Survivors</td>
<td>22</td>
<td>8</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>36.4%</td>
<td>63.6%</td>
<td></td>
</tr>
<tr>
<td>Deceased</td>
<td>36</td>
<td>5</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.9%</td>
<td>86.1%</td>
<td></td>
</tr>
</tbody>
</table>

Overall Accuracy = 67.24%

Cross-Validation Sample Classification Results

<table>
<thead>
<tr>
<th>Actual Group</th>
<th>N</th>
<th>Predicted</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Survivors</td>
<td>Deceased</td>
<td></td>
</tr>
<tr>
<td>Survivors</td>
<td>18</td>
<td>6</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>33.3%</td>
<td>66.7%</td>
<td></td>
</tr>
<tr>
<td>Deceased</td>
<td>34</td>
<td>5</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.7%</td>
<td>85.3%</td>
<td></td>
</tr>
</tbody>
</table>

Overall Accuracy = 67.31
Table 11
Stepwise Discriminant Function Analysis including only Dietary Variables without a Holdout Sample

<table>
<thead>
<tr>
<th>Actual Group</th>
<th>N</th>
<th>Predicted</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Survivors</td>
<td>Deceased</td>
<td></td>
</tr>
<tr>
<td>Survivors</td>
<td>40</td>
<td>16</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>40.0%</td>
<td>60.0%</td>
<td></td>
</tr>
<tr>
<td>Deceased</td>
<td>70</td>
<td>15</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>21.4%</td>
<td>78.6%</td>
<td></td>
</tr>
</tbody>
</table>

Overall Accuracy = 64.55%
Table 12

Direct Discriminant Analysis Including only the Dietary Variables with a Holdout Sample

| Analysis Sample Classification Results | | | |
|--------------------------------------|---|---|
| Actual Group                | N | Predicted Survivors | Deceased |
| Survivors                    | 18 | 2 | 16 |
|                            |   | 11.1% | 88.9% |
| Deceased                    | 34 | 0 | 34 |
|                            |   | 0% | 100% |

Overall Accuracy = 69.23%

| Cross-Validation Classification Results | | | |
|---------------------------------------|---|---|
| Actual Group                | N | Predicted Survivors | Deceased |
| Survivors                    | 22 | 4 | 18 |
|                            |   | 18.2% | 81.8% |
| Deceased                    | 36 | 2 | 34 |
|                            |   | 5.6% | 94.4% |

Overall Accuracy = 65.52%
### Table 13
Stepwise Multiple Regression Analysis Including the Demographic/Medical History Variables with only Deceased Subjects

<table>
<thead>
<tr>
<th>Step Entered</th>
<th>Variable</th>
<th>Adjusted $R^2$</th>
<th>df</th>
<th>$F$</th>
<th>$p$</th>
<th>Beta Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Onset</td>
<td>.14</td>
<td>1,68</td>
<td>12.26</td>
<td>.001</td>
<td>-.3908</td>
</tr>
<tr>
<td>2</td>
<td>Age</td>
<td>.44</td>
<td>2,67</td>
<td>23.27</td>
<td>.0001</td>
<td>1.8463</td>
</tr>
</tbody>
</table>
CURRICULUM VITA

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DOCTORAL EXAMINATION AND DISSERTATION REPORT

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Major Field: Psychology

Title of Dissertation: The Role of Dietary Compliance in Survival of Hemodialysis Patients

Approved:

[Signature]

Major Professor and Chairman

[Signature]

Dean of the Graduate School

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Date of Examination: March 3, 1988