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The relationship of nutritional status, personality hardiness, and social support of the older adult to treatment outcomes following non-emergent cardiac surgery

Myers, Sally Ann, Dr.P.H.

University of Hawaii, 1993

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THE RELATIONSHIP OF NUTRITIONAL STATUS, PERSONALITY HARDINESS, AND SOCIAL SUPPORT OF THE OLDER ADULT TO TREATMENT OUTCOMES FOLLOWING NON-EMERGENT CARDIAC SURGERY

A DISSERTATION SUBMITTED TO GRADUATE DIVISION OF THE UNIVERSITY OF HAWAII IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PUBLIC HEALTH

MAY 1993

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DEDICATION

This work is dedicated to my late husband, Dr. Robert L. Myers who encouraged me to be my very best, to my late mentor, Dr. Charlie Rose who gave me courage to keep on going, to my patients who inspire me to ask new questions, and to my family and friends who continue to love me through very difficult times.
ACKNOWLEDGMENTS

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ABSTRACT

The purpose of this public health study was to examine the relationships between pre-treatment, personal characteristics (nutritional status, personality hardiness, social support) in older adults and surgical outcomes (increased postoperative complications and lengths of acute hospital stay) following non emergent cardiac surgery. A convenience sample of 52 subjects (men = 38, women = 14), 60 years of age and older, entered the study prior to surgery between February 23, 1992, and September 3, 1992. Forty-eight percent of the sample subjects were Japanese Americans.

The study, using tools selected from the research literature on personality hardiness (Kobasa, 1991), social support (Tilden, 1991), and nutritional status (Blackburn, Bistrian, Maini, Schlamm, & Smith, 1977), measured characteristics in each of the subjects while controlling for age sex, socioeconomic status, and severity of illness.

One population (total sample) and two population models (men and women separately) were analyzed statistically. Study hypotheses were not supported due to the directional relationship of the study variables to the outcome variables. Albumin, a nutritional status indicator, was the most consistent variable in prediction of hospital length of stay in all three models (one population and two population models). Age and ejection fraction were the most consistent predictors of postoperative intensive care hours. Personality hardiness was negatively related and a strong predictor of hospital length of stay in men but only a weak relationship was found in women. Social support was negatively related and a predictor of postoperative intensive care hours in women, but was
positively related to hospital length of stay and number of intensive care hours in the total sample and in men's sample.

Although the study hypotheses were not supported primarily due to directional relationships of the study variables to outcome variables, statistically significant subset regression models did predict acute hospital length of stay for the total sample (p = 0.0235) and for men (p = 0.0359). Statistically significant subset models also predicted number of intensive care hours (a measure of postoperative complications) for the total sample (p = 0.0004) as well as for men (p = 0.0001) and women (p = 0.0077) separately.
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CHAPTER 1
INTRODUCTION

Predicting successful outcomes for planned surgical treatment of older adults is dependent on identifying the important biological, psychological, social, and environmental factors in a person's life which may impact outcomes. Controlling, reducing, or eliminating identifiable biological risk factors prior to surgical intervention improves outcomes in most procedures. In addition, many medical and nursing practitioners believe that the "state of mind" and family support, particularly in the older adult, significantly affects outcomes. However, the impact of non-biomedical factors—i.e., psychological, social, and environmental factors—on outcomes of major surgery has not been well documented in older patients. With the burgeoning increase in our older population and the concomitant increase in major surgery in the elderly patient, it is imperative to determine the influence of major biological, psychosocial, and environmental factors on risk in the individual patient. The determinants of risk will improve the quality of informed consent as well as establishing standards and guidelines for treatment of older patients that are based on quantitative data and not on vague impressions.

Biological, psychological, and social theories of stress resistance have a growing body of supporting research (Kobasa, Maddi, Puccetti, & Zola, 1985). However, biological, psychological, and social concepts within those theories of stress resistance have been primarily defined and tested in the isolation of each researcher's discipline (Kobasa,
1979; Sarason, Levine, Basham, & Sarason, 1976; Lambert, Lambert, Klipple, & Mewshaw, 1990). Biomedical research has primarily tested biological (genetic and environmental) outcomes and physiological responses to stress as they vary by age. Practitioners in psychology and sociology have studied personality characteristics and sociological forces that contribute to "successful" stress resistance and successful aging. These concepts have only recently been tested in relationship to each other and to quantifiable treatment outcomes (Polluck, 1986).

The combination of carefully measured biological, psychological, and social components of an individual should provide a discriminating preoperative predictive value for surgical risk and offers the possibility of improving outcomes in the high risk group. Developed within Kobasa's theoretical framework of personality hardiness, this prospective study examined the relationship of an individual's nutritional status as a reflection of personal health, personality hardiness, social support, severity of illness, age, sex, and socioeconomic status to outcomes of planned surgical treatment.

**Significance of the Study**

Since the introduction of prospective payment by diagnostic related groups (DRG) in 1982, acute care hospitals, which consume over 60 percent of the health care dollar, attempt to control complications in all patients that result in long hospital stays. Patients who are 65 years of age and older account for 40 percent of hospital expenditures and contribute only 32 percent of 1990 revenues at The Queen's Medical Center in Honolulu, Hawaii, a five-hundred-bed, community hospital. In
the past, these financial losses were cross-subsidized by payments from private insurance companies. But now, private health insurance companies closely scrutinize costs and use prospective payment plans similar to governmental programs.

Successful treatment outcomes have always been important for humanistic reasons. However, financial pressures and the increasing proportion of older patients are driving health care institutions to study, develop, and possibly allocate financial support to new approaches for treatment intervention. Most patients scheduled for non-emergent or elective surgery have preoperative instruction and routine laboratory screening done prior to admission. Anyone requiring special treatment for uncontrolled diabetes, heart disease, or other chronic illness is referred for treatment prior to admission. Admission of patients on the day of surgery rather than the preceding evening has resulted in financial savings to government and private health insurance agencies.

Biomedical problems are screened and controlled prior to the stress of surgery, but patients still have unanticipated complications and long hospital stays.

Age is believed to be a major factor in prolongation of hospital stay. Many factors, which influence the outcome potential and predispose the older adult to prolonged illness and long hospital stays, cannot be controlled at the time treatment is needed. Genetic predisposition cannot be altered, a long history of environmental exposure to toxic pollutants cannot be erased, nor can a social support system be magically created. Correctable conditions such as
uncontrolled chronic conditions or malnutrition can be improved or, if the treatment poses more risk than benefit, alternative treatments may be chosen. Patients and families can be given new information to help them deal with and control the stress of hospitalization and the post-hospital support that will be needed. Identifying those personal risk factors which can be safely altered in relationship to treatment outcomes may be crucial in making therapy decisions and planning supporting programs.

The prevalence of malnutrition among surgical patients has become an increasingly recognized problem in acute care hospitals. Some studies have shown that as many as 60 percent of all hospitalized patients in the United States have moderate to severe malnutrition as defined by the World Health Organization (Butterworth, 1974; Bistrian, Blackburn, Hallowell, & Haddle, 1974; Bistrian, Blackburn, Vitale, Cockran, & Naylor, 1976; Blackburn, Bistrian, Maini, Schlamm, & Smith, 1977; Mullen, Gertner, & Busby, 1979). Research has repeatedly linked malnutrition to poor treatment outcomes and longer lengths of hospital stay, but only a few studies have addressed problems specific to the older adult (Polly & Sander, 1977; McGeer, Detsky, & O’Rourke, 1989). Predictive models comprised of nutritional variables alone (Buzby, Mullen, Matthews, Hobbs, & Rosato, 1980) are not supported in follow-up studies (Foster, Heppenstall, Freidenberg & Hozack, 1990). Also, social support and the patient’s personal hardiness contribute to an individual’s coping with illness and may confound the relationship between malnutrition to surgical outcomes. A correctly specified
predictive model should include these variables as well as nutritional status.

Studies completed during the past 15 years indicate that malnutrition is a major contributor to complications and long hospital stays among surgical patients. Thus programs which can detect sub-clinical or potential malnutrition and treat prior to elective medical treatment—i.e., non-emergent surgery—are likely to reduce complications secondary to malnutrition and to decrease the acute length of stay. Reliable predictive models can result in the development of preventive programs and better treatment outcomes.

The specific aims of this dissertation research are to determine if older adults scheduled for non-emergent, cardiac surgery have nutritional, personality, and social characteristics which are related to poor treatment outcomes.

Relevance to Public Health

The expenditure of public funds for hospital care of the elderly and the tragedy of those elderly people who spend their last weeks in an intensive care unit, dying after a seemingly "successful" surgery, require specific attention to the unique factors related to age.

The concept of prevention is promoted by society and by health professionals in community and clinical settings. Inoculation programs, well-baby clinics, prenatal care, and food banks are acclaimed and financially supported. Public health programs directed toward detection and prevention, however, generally do not include patients who are hospitalized. Malnutrition, which has been identified as a major
contributor to hospital complications in as many as 50 percent of older patients, has received little acknowledgment outside the clinical setting (Butterworth, 1974; Bistrian, Blackburn, Hallowell, & Haddle, 1974; Bistrian, Blackburn, Vitale, Cockran, & Naylor, 1976; Blackburn, Bistrian, Maini, Schlamm, & Smith, 1977; Hill, Pickford, & Young, 1977; Beaumont, Lehmann, & James, 1989; Campbell, Spears, Brown, Busby, & Borrie, 1990). Malnutrition of in the clinical setting has received very little attention in public health programs because it is perceived as purely iatrogenic and not a reflection of a community problem. But as Jelliffe and Jelliffe (1989) explain, public health problems in subgroups are frequently brought to the community's awareness following detection in the clinical setting. The problems are then further examined, verified, and put into context by epidemiologists and public health teams. Commitment to correct deficiencies depends on the financial impact of the problem and the community's social priorities.

Treatment of malnutrition in elderly adults has only recently become recognized as a major problem in industrialized countries (Dibble, Brin, Thiele, Peel, Chen, & McMullen, 1967; Yearick, 1978; Beauchene & Davis, 1979; Garry, Goodwin, Hunt, & Gilbert, 1982; Jelliffe & Jelliffe, 1989). In a Swedish study Thorslund and colleagues (1990) conclude that protein-energy malnutrition, in the degree shown to impair hospital prognosis, also occurs in elderly people living at home in an industrialized country. In 1971, the White House Conference on Aging estimated that one third to one half of the health problems of the elderly are related to malnutrition (Natow & Heslin, 1980). During the past 15 years sub-clinical malnutrition of the chronically ill, the
majority of whom are elderly, has been detected more frequently with hospital admissions and during outpatient care (Butterworth, 1974; Blackburn et al., 1977). This indicates that malnutrition is not only iatrogenic but prevalent within the community, especially in the older adult.

Malnutrition in hospitalized patients became a financial consideration in 1982. In order to control spiraling costs of hospital care, Medicare, the governmental health insurance agency of people over 65 years of age, instituted a financial cap on hospital reimbursement through the Prospective Payment System (PPS) and Diagnosis Related Group (DRG) compensation program. (Tax Equity and Fiscal Responsibility Act, 1982). Public and private hospitals were suddenly faced with a finite amount of money and time limits in which to treat elderly patients who comprised 40 to 60 percent of their inpatient population. Additionally, private health insurers began to adopt the PPS of reimbursement. A hospital's financial survival became dependent on providing well-documented treatment within a prescribed time frame.

Complications related to malnutrition in the elderly are now recognized as major contributors to hospital costs. Early detection and treatment of malnutrition in the acute care setting prior to clinical intervention have been supported in the medical literature since the early nineteen seventies (Bistrian et al., 1974; Seltzer et al., 1981; Muller, Brenner, Dienst, & Pichmaier, 1982). However, the financial justification for prevention programs prior to admission to acute care facilities has been problematic. Malnutrition of the elderly in the community has not been widely recognized nor documented in American
epidemiological studies. The primary health care provider, the physician, who generally initiates entry into the hospital setting, has very little formal preparation in detecting malnutrition. Patients are frequently admitted to hospitals on the day of surgery and nutritional status may not be fully evaluated by the hospital team until 48 to 72 hours after treatment. Detection of sub-clinical malnutrition is difficult and dependent on experienced clinicians who understand the fallacies of the measurement tools and the lack of specificity of those tools when applied to the older adult. Due to lack of scientific evidence that clearly supports an over-all cost reduction and a decreased length of stay, pre-clinical, outpatient prevention programs, which require expensive laboratory procedures and personnel time, have not been attempted by acute care facilities except under a small number of research grants.

In 1987, the average American's health care expenditure was $1758. Hospital care counted for 44 percent of personal health expenditures (Letsch, Levit, & Waldo, 1988). Twelve percent of the 1987 population was comprised of elderly adults who consumed 36 percent of the health care dollar (Waldo, Sonnefeld, McKusick, & Arnett, 1989). Medicare, the largest public financier of health care, provided $81 billion in health services to 32.4 million aged and disabled enrollees in 1987. The majority of Medicare benefits, 66 percent, purchased hospital care, and another 27 percent bought physicians' services (Letsch et al., 1988). If the 1971 White House Conference was conservatively correct in its estimation that 33 percent of the diseases in the elderly were related to nutritional disorders, $27 billion (33% of $81 billion) might be more
appropriately designated for detection and prevention of malnutrition and the related diseases in the elderly.

**Purpose of the Study**

The purpose of this study is to determine if there are relationships between pre-treatment personal characteristics (nutritional status, personality hardiness, social support) and treatment outcomes including complications, death, and increased lengths of hospital stay in elderly patients following non-emergent cardiac surgery.

**Theoretical Framework**

The human body is genetically programmed at conception for a finite life span (Hayflick, 1965). Some biological elements, determined by family history, are stronger than others in resistance to disease and illness. The stress of day-to-day living or the wear and tear of life (Selye, 1956) gradually takes its toll on the human body and diminishes reserve capacities (Lipschitz. 1986). However, certain environmental factors such as health practices (nutrition), the person's own hardiness, and social supports probably contribute to each person's ability to sustain life longer and to avoid frequent or prolonged episodes of illness (Kobasa, 1979). At this time genetic predisposition is difficult to alter. Health practices, personality, and social factors may be more amenable to intervention. This study has been designed within Kobasa's conceptual framework (1985) which incorporates Selye's theory of stress resistance (1956) and reflects Hayflick's
theory of aging (1965) and Lipschitz's (1987) concept of diminished reserve capacity (Figure 1).

Kobasa's hardiness model (1985) is a model of stress resistance: Individuals with a high degree of personality hardiness, when facing stressful life events will be less likely to become ill. Within the model the filters—the semicircles followed by broken lines—indicate that certain factors, when present, can diminish the effects of stress on illness. One form of filter can be health practices, such as good nutrition, as seen by the flow of the arrows within the framework. Pearlin and colleagues (1981) refer to such interventions as "mediating factors" in the stress response. The link between stress and illness is not direct. Selye's theory (1956) proposes that an imbalance of the neuroendocrine system due to prolonged stress gradually produces illness.

Constitutional predisposition is one's genetic endowment. Constitutional predisposition's may be abstracted from a family history of illnesses—specifically, information about present health and ages of parents and siblings at the time of death. A score is derived by adding the raw frequency of illnesses of the subject's parents and dividing by the sum of the parents' age (Kobasa, Maddi, & Courington, 1981). Organismic strain is stress or "manifestations of stress" (Pearlin, Menaghan, Lieberman, & Mullen, 1981) resulting from life events and chronic life strains converging at one time. Organismic strain is experienced as noxious. Examples include loss of a spouse or a loss of financial security. An example pertinent to the present study would be non-emergent cardiac surgery. Pearlin and colleagues (1981) emphasize
Figure 1: Kobasa's Conceptual Framework
that adverse consequences to life events depend on the number of events, the magnitude of the changes they entail, and the quality of the eventful change. Although not explicitly expressed in Kobasa's model or the supporting psychological literature, this study will include in the definition of organismic strain the concept of diminished reserve capacity due to advancing age (Hayflick, 1965; Lipschitz, 1986). (The relationship of aging to Kobasa's theoretical framework has not been reported in the literature.) The first level of Kobasa's framework combines two theories of stress response—the theory of stress or the normal wear and tear on the body and the theory of biomedical aging which projects that the body literally runs out of reserves (Selye, 1956; Hayflick, 1965).

The second level of Kobasa's framework develops the concepts of stress resistance. Personality hardiness is a "personality style or set of general attitudes toward self and the world that expresses (1) commitment to self, work, family, and other areas of involvement, (2) control or belief in the ability to influence what occurs in one's life space, and (3) challenge or an interest in change and new experiences" (Kobasa, 1985). Social support means "access to and use of individuals, groups, or organizations in dealing with life's vicissitudes" (Pearlin et al., 1981). Kobasa and colleagues (1983) have reported conflicting influences of social support depending on the source (supervisors at work versus family). Transformational coping is the modification of the situation giving rise to a stressful problem. It is likely to encompass one or more of the following: information seeking, direct action, intrapsychic process, or turning to others for support (Pearlin et al.,
1981; Cohen, 1984). Transformational coping could be the focus concept for future program development stress mediation. Kobasa defines health practices as those actions a person takes to help relieve stressful situations and can include any activity most relevant to that person's immediate needs: a relaxing warm bath, playing tennis, jogging, reading, meditation, seeking medical attention, taking vitamins, etc. Exercise as a health-practice resource against illness was examined by Kobasa, Maddi, Puccetti, and Zola (1985). Exercise provided a relatively small effect when compared to personality hardiness. In this study health practices will be measured by the person's nutritional status.
CHAPTER 2
REVIEW OF THE LITERATURE

Review of the literature has indicated that the concepts defined within this study have not been studied together. The concepts of personality hardiness and social support are substantiated in psychological and nursing literature (Kobasa, Maddi, Puccetti, & Zola, 1985; Polluck, 1986; Lambert, Lambert, Klipple, & Mewshaw, 1990). Malnutrition related to postoperative outcomes is represented in medical and nutritional literature, but very little has been related to individual personality, social support or to a specific group, the older adult. In addition, there are no reported studies that relate the older adult's pre-hospital nutritional status or personality hardiness to surgical outcomes. The concept of social support from a significant other or others in relationship to surgical outcomes has had some investigation. The clinical staff premise that people who do not have a supporting significant other or a source of good social support do not do as well has not been reported in a research format.

Postoperative Outcomes and Length of Stay Related to Nutritional Status

A large body of medical-nutritional literature has been devoted to identifying and correcting malnutrition in hospitalized patients during the past 15 years. Tools developed by the World Health Organization to detect malnutrition in Third World Countries (Jelliffe, 1966) have been applied in acute care settings (Blackburn, et al., 1977) with varying
degrees of success. New techniques in the measurement of malnutrition have been developed and supported or refuted through continuing research (Buzby, Mullen, Matthews, Hobbs, & Rosato, 1980). Techniques accepted in Third World research have been questioned or refuted in the acute care setting (Jelliffe, 1989) or in specific populations such as the older adult (Karkeck, 1985).

Treatment of malnutrition in acute care patients has become a multimillion-dollar industry since Dudrick (1968) first demonstrated that nutrition could be successfully provided intravenously. Sophisticated intravenous and enteral formulas have been devised specifically to address complex pathophysiological conditions including prematurity, hepatic insufficiency, and immunosuppression. These complex forms of treatment demand specialized teams of health professionals to administer the treatments in order to avoid complications which are identified with hypertonic solutions and invasive equipment.

The escalating cost of health care and the adoption of prospective payment in acute care hospitals during 1985 focused attention on high-cost therapies including nutritional support. Predicting what nutritional indicators or measurements were the most cost effective in detecting malnutrition became important in the medical literature. It also became imperative to demonstrate that nutritional support teams were more effective in delivering expensive therapies and, ultimately, that high-cost nutritional therapies contributed to successful treatment outcomes—i.e., decreased complications and decreased hospital days for patients over 65 years of age. Several authors (Buzby et al., 1980;
Hall, 1990) attempted to develop prognostic tools or single indicators (Klidjian, Archer, Foster, & Karran, 1982) which would predict surgical outcomes.

Overt malnutrition has been reported in both medical and surgical patients. The condition is frequently due to iatrogenic or hospital-induced practices. Butterworth (1974) identified hospital malnutrition in a dramatic article, "Skeleton in the Hospital Closet", in *Nutrition Today*. Patients are not provided adequate calories during or after invasive treatment. For example, they may receive only intravenous glucose (200 calories per liter or approximately 600 calories per day) for several days following surgery. Diagnostic procedures which require no intake of food or water by mouth may interrupt several meals over several days. As a result of this work and the efforts of nutrition support teams, health care personnel have become more aware of the problem. Yet, patients still lose weight and become malnourished due to the system of providing health care.

Body weight is a primary indicator of change in nutritional status in hospitals, clinics, physician offices, and research surveys (Gambert & Guansing, 1980; Thorslund, Toss, Nilsson, Schenck, Symreng & Zetterqvist, 1990; Manson and Shea, 1991). Significant deviations (10%) either above or below normal standards (Metropolitan Life Insurance Height for Weight Tables, 1983) or evidence of involuntary weight loss of 15 percent or more of usual body weight (Sullivan, Walls, & Lipschitz, 1991) suggest risk of malnutrition and are associated with increased morbidity or mortality (White, 1991). Low body weight has been associated with increasing mortality in the elderly within the
community (Campbell et al., 1990) and increased morbidity in men undergoing open heart surgery (Abel, Fisch, Horowitz, van Gelder, & Grossman, 1983). In a study of patients undergoing elective colorectal surgery, de la Hunt and colleagues (1983) found a 72 percent incidence of complications in patients with low body weight (compared to Metropolitan Life Insurance tables). Obesity as well as low body weight is associated with increased risk of complications following surgery. Ulicny and colleagues (1990) reported an increased incidence of sternal wound infections following cardiac surgery related to obesity. Lew and Garfinkel (1979) showed an increased mortality ratio in overweight subjects but those ratios decreased with age and were closer to unity for those 80 to 89 years of age. On the other hand, Burr, Lennings, & Milbank (1982) found that subjects surviving over the age of 70 years tended to be heavier than those who died which may indicate that an above-average weight may be a favorable prognostic factor in old age.

The most consistent predictor of protein-calorie malnutrition in any age group is serum albumin (Mitchell & Lipschitz, 1982). In the young and healthy older subject, a value below 4 grams per deciliter is very unusual. Serum albumin has been reported as a major predictor of postoperative complications in several studies (Buzby et al., 1980; Jensen, Jensen, Smith, Johnston, & Dudrick, 1982; Broden, Bark, Nordenvall, & Blackman, 1984; Sullivan et al., 1991). Longer hospital stays related to low preadmission serum albumin have also been reported (Anderson & Wochos, 1982). Low serum albumin (less than 3.5 grams per deciliter) preoperatively has been linked to postoperative complications, increased hospital lengths of stay, and death in elderly

Postoperative Outcomes and Length of Stay

Related to Personality Hardiness

Health care professionals in clinical settings frequently predict outcomes based on the patient's response to illness—i.e., patients who control their treatments, who are inquisitive, overtly angry or fighting for control are believed to have better outcomes. Patients who are considered passive, depressed, and who accept treatment without question are viewed as less successful. However, this concept of subjective prediction based on the patient's personality has not been widely tested in relationship to actual treatment outcomes.

Personality hardiness, a concept introduced by Kobasa (1979), was designed to predict illness episodes in male executives. Building on the work of Selye (1956), Holmes and Rahe (1967), and Rabkin & Struening (1976), Kobasa supported work showing a low correlation ($r = 0.30$) between stressful events and illness (Kobasa, Maddi, & Kahn, 1982). She hypothesizes that this low correlation is due to the wide variability among individuals and the "resistance resources" of various individuals (Kobasa, Maddi, & Courington, 1981). Some people with very high stress seldom become ill while others with high stress are ill more frequently. In the initial study (Kobasa, 1979), male business executives who had high stress and a low incidence of illness scored higher on measures of hardiness than did the executives who had high stress and a high incidence of illness. In a 1982 study, Kobasa found hardiness to be a
significant predictor of fewer illness symptoms and to serve as a mediator of stress as the number of stressful life events increased. This hardiness-illness hypothesis was further supported by Lambert & Lambert (1987) who tested psychological well-being in women with rheumatoid arthritis in relationship to social support, personality hardiness, and severity of illness.

Personality hardiness "... is a personality style consisting of interrelated orientations of commitment (vs. alienation), control (vs. powerlessness), and challenge (vs. threat)" (Kobasa, Maddi, Puccetti and Zola, 1985). People with high commitment are curious, interested, and become easily involved in activity around them. People with a strong internal control believe and act to influence those events within their environment. Challenge is perceived as opportunity for personal development (Kobasa, et al., 1985). Research by Kobasa and colleagues has supported personality hardiness as a predictor of illness in male executives. Personality hardiness has had limited testing in women and has not been tested in elderly adults. Knoop (1989) questions whether aging and life events following retirement may refocus a person with internal control to more external relationships.

Personality hardiness in relationship to illness has been supported by Kobasa and colleagues (Kobasa, 1979; Kobasa, Maddi, & Courington, 1981; Kobasa, 1982; Kobasa, Maddi, & Kahn, 1982; Kobasa, Maddi, Puccetti, & Zola, 1985; Kobasa & Puccetti, 1983) and health professionals (Lee, 1983; Polluck, 1986; Lambert, Lambert, Klippie, & Mewshaw, 1990).
Kobasa's work supports the concept of personality as a resistant force against illness or a reduced level of symptoms from illness. This short term, prospective study will address the role that personality hardiness plays in the recovery of older adults following planned surgery. As suggested by Kobasa (1979) hardiness will be measured at time prior to the stress episode—open heart surgery.

**Postoperative Outcomes and Length of Stay**

**Related to Social Support**

Physicians and other health care personnel frequently comment on the importance of the support of a "significant other" person to the favorable outcome of treatment. Patients who are "alone" just do not seem to do as well. Although this concept is an integral part of clinical care, the importance of a good relationship with a significant other to the successful outcome of treatment is not well tested nor discussed in health care literature.

Social support is defined as the existence or availability of individuals on whom one can rely for love and assistance (Sarason, Levine, Basham, & Sarason, 1983). Social support tends to modify the negative effects of stressful situations by reducing stress or by facilitating the individual's efforts to cope with stress (Rabkin & Struening, 1976; Dean & Lin, 1977; Eaton, 1978; House, 1981; Northouse, 1982). Social resources such as education, wealth, and majority status in society are less critical than perceived support from others (Cobb, 1976). Individuals with good social support exhibit lower incidence of somatic illness, have a higher morale, and demonstrate positive mental
health (Gore, 1978). Some studies report social support as the main effect in maintaining health whereas others find that social support is a buffer (Gore, 1978). Associations between social support and psychological well-being have been found in studies of new mothers with difficulties in parenting roles; adults with hearing loss; functionally psychotic patients (Turner, 1981); and women with rheumatoid arthritis (Lambert, Lambert, Klipple, & Mewshaw, 1990). Other studies have had varying outcomes (Kobasa, & Puccetti, 1983; Lambert, 1985).

Postoperative Outcomes and Length of Stay Related to Age

Multiple studies have been reported on surgical treatment outcomes in relation to chronological age (McIntyre, Ballenger, & King, 1990; Horneffer, Gardner, & Manolio, 1987). Many of these studies have found no significant relationship between age and treatment outcomes. Other variables have been more important (Broden, Bark, Nordenvall & Backman, 1984). Perioperative mortality rates, however, increase with age for patients undergoing coronary artery bypass surgery (Kennedy, Kaiser, Fisher 1981; Gersh, Kronmal, Frye, 1983; Cosgrove, Loop, Lytle, 1984; Horneffer, Gardner, Manolio, 1987; Loop, Lytle, Cosgrouve, 1988), aortic valve replacement (Craver, Goldstein, Jones, Knapp, & Hatcher, 1984; Magovern, Pennock, Campbell, 1987; Craver, Weintraub, Jones, Guyton, & Hatcher, 1988;), or mitral valve replacement (Fremes, Goldman, Ivanov, Weisel, David, Salerno, 1989; Jamieson, Burr, Munro, Miyagishima, Gerein, 1989; Czer, Gray, DeRobertis, 1984) with or without coronary artery bypass (Freeman, Schaff, O'Brian, Orszulak, Naessens, Tajik, 1991).
Freeman and colleagues (1991) reported an overall thirty-day postoperative cardiac mortality of 15.7 percent in patients 80 years of age and older at the Mayo Clinic (n=191). The mean postoperative hospital stay was 16.4 ± 13.3 days. The perioperative mortality rate for elective surgery in this elderly group was: coronary artery bypass (5.6%), aortic valve replacement (9.6%), aortic valve with coronary bypass (17.9%), and mitral valve surgery with or without coronary bypass (21.4%). The overall perioperative mortality rate was 2.5 times greater in patients having urgent versus elective surgical procedures. A borderline statistical predictor of early hospital mortality in Freeman's study included age over 85 years (p = 0.060). Length of stay for the various subgroups was not reported.

Postoperative Outcomes and Length of Stay Related to Gender

A number of studies have reported that women have a higher risk of death following primary myocardial revascularization (Kennedy, Kaiser, Fisher, 1980; Loop, Golding, & Macmillan, 1983). Fisher, Kennedy, & Davis (1982), however, concluded that the operative mortality rate is greater in women because of smaller body and coronary vessel size. Gibson and Loop (1986) also concurred that body surface area was the strongest predictor of operative death. Female gender does not appear to be predictive of increased perioperative mortality rates from valve procedures (Christakis, Weisel, David, 1988; Christakis, Weisel, David, 1988). No studies have been found which report body size in relationship to race. For example, do smaller Asian men have a higher risk of mortality than Caucasian men of similar size?
Postoperative Outcomes and Length of Stay Related to Socioeconomic Status

Socioeconomic status may be measured by family of origin, level of education, income status, or current or past employment position (Greemberg, Haber, Clark, Bockman, Liff, et al., 1991;). Medical studies have used preoperative medical insurance status as another indicator of socioeconomic status (Martin, Tan, Holmes, Becker, Horn, et al., 1991).

Epstein, Stern, and Weissman (1990) found in two studies that patients of the lowest socioeconomic status had 21 percent longer hospital stays and 13 percent higher charges for hospitalization than those patients of high socioeconomic status. Epstein and colleagues used three measures of socioeconomic status: income, occupation, and education.

Level of education has been used to predict socioeconomic status of men (Duncan, 1972; Hout, 1983; Zurayk, Halabi, & Deeb, 1987; Sorel, Ragland, Syme, & Davis, 1992), in studies of disease prevalence (Winkleby, Fortmann, & Barrett, 1990), and as a major factor in medical treatment outcomes (Ciccone, Magnani, Delsedime & Vineis, 1991; Cella, Orav, Kornblith, Holland, Silberfarb, et al., 1991; Mandal, Kauskik, & Oparah, 1991). Following the work of Lund and Jacobsen (1991), this study comprised of older adults used level of education as the main indicator of socioeconomic status.

Postoperative Outcomes and Length of Stay Related to Severity of Illness

Severity of illness may be difficult to measure in older adults due to the common presence of multiple system problems. Several secondary
diagnoses may be present at the time the patient requires open heart surgery. Secondary diagnoses may or may not be presented completely on the medical record. Frequently, only the secondary diagnoses related to the primary admitting problem are included. The secondary diagnoses and contributing risk factors typically include histories of smoking, myocardial infarction (MI), hypertension, cerebral vascular accidents (CVA), diabetes, and prior open heart surgeries (OHS).

Severity of illness may also be quantified by the number of diseased vessels or the number of grafts done during the bypass operation. Reports in the literature indicate that fewer vessels grafted at time of surgery are associated with a higher and earlier mortality rate in women (Gersh et al., 1981). Recently, left ventricular ejection fraction has been used as an indicator of severity of heart disease. Hannan and colleagues (1990), Mattila, Ventro, Ristikankare, and Mattila (1990), and Ko and colleagues (1991) found the left ventricular ejection fraction a consistent predictor of operative mortality. Ko’s group (1991) ranked all ejection fractions which were recorded as a percentage or a rank of good, fair, or poor. Preoperative ejection fractions of greater than 50 percent (>50%) were considered good, fair if 30 to 50 percent (30% to 50%), and poor if less than 30 percent (<30%).
CHAPTER 3

METHODOLOGY

This study examines how selected preoperative characteristics predict surgical outcomes (number of hours in intensive care, acute hospital length of stay, and death) of patients, 60 years and older, undergoing elective open heart surgery. All cardiac surgeons (n = 8) in this 506 bed general, community hospital referred patients into the study. A prior retrospective study conducted by The Queen’s Medical Center (unpublished) from 1991 through 1992 indicated an equal in hospital morbidity and mortality record for all eight surgeons. A convenience sample of 52 patients scheduled for elective open heart surgery in this community hospital was selected for this prospective study over a six-month period from February 28, 1992, through September 3, 1992. Open heart procedures in this sample included coronary artery bypass grafts (CABG) and valvular replacement (tricuspid valve replacement: TVR, aortic valve replacement: AVR, and mitral valve replacement: MVR) or a combination of the above procedures. All of the selected patients were living independently within the community and were able to manage self care including shopping. Each subject had walked to the interview or to the preceding cardiac catheterization procedure.

Demographic information (age, ethnicity, marital status, level of education, and area of residence), anthropometric measurements (height, weight, percent of ideal body weight, and biochemical measurements through blood tests (serum albumin) were collected. Two surveys of
personality hardiness (Kobasa, 1991) and social support (Tilden, Nelson, May, 1990) were completed by each patient. The acute hospital length of stay days and the number of hours in the intensive care unit following surgery were obtained from the hospital record. Additional information from the medical record included the number of secondary diagnoses, the left ventricular ejection fraction as an indicator of severity of illness, the actual surgical procedures, and the discharge status.

**Study Question**

The research question addressed by this study was as follows: What are the relationships of an older adult's nutritional status, personality hardiness, and social support (controlling for the severity of illness, socioeconomic status, sex, ethnicity, and age) to postoperative complications (intensive care hours) and the duration of acute hospitalization following non-emergent surgical treatment?

**Hypotheses**

Controlling for the intervening variables of severity of illness, age, sex, ethnicity, and socioeconomic status:

Older adults with a good nutritional status, positive personality hardiness, and positive social support prior to hospitalization will have fewer hours in the intensive care following planned surgical treatment.
Older adults with a good nutritional status, positive personality hardness, and positive social support prior to hospitalization will have a shorter acute hospital length of stay following planned surgical treatment.

**Study Design and Sample**

This was a prospective study of the relationships of a patient's individual characteristics to surgical treatment outcomes.

The target population for this prospective study consisted of men and women over the age of 60 years undergoing non-emergent, elective surgery at The Queen's Medical Center, a five-hundred-six-bed community hospital in Honolulu, Hawaii. A convenience sample of men and women patients was referred by cardiac surgeons with comparable surgical morbidity and mortality outcomes. The sample subjects were obtained from patients scheduled for non-emergent surgery between February 23, 1992 and September 3, 1992. The criteria for inclusion in this study were: (a) 60 years of age or older, (b) functional capability to walk into the facility for testing prior to surgery, (c) surgery scheduled no sooner than 24 hours, (d) English reading and speaking capability, (e) no known psychiatric disorder, (f) no recent (within past six months) stressful psychological event—i.e., death of spouse or significant other, divorce or separation, or loss of employment in past year, and (g) no acute episode of any acute or chronic disease other than the heart disease requiring hospitalization in the past six months.
Variables

Dependent Variables: Hospital acute length of stay
Intensive Care Length of Stay

Independent Variables: Nutritional Status
Personality Hardiness
Social Support

Confounding Variables: Age in years
Severity of Illness
Sex
Ethnicity
Socioeconomic Status

Definitions

Hospital Acute Length of Stay. The length of time in days during which the patient is confined to the hospital for acute care, including the first day after admission through the day of discharge from the hospital or the day the level of care is downgraded to a lower level (non-acute) of care. Patients who required placement in an extended care facility following treatment were counted acute care until their status was formally changed by the attending physician. The number of days required for the acute hospital length of stay indicates the ability of the patient to return to normal life. The number of days was collected from the medical record.

Intensive Care Unit Following Length of Stay. The number of hours the patient spent in the intensive care unit following surgery was used
to represent the postoperative complications. The number of hours was collected from the medical record.

**Nutritional Status** is the physical condition of the subject that reflects the adequate or inadequate intake of nutrient foods and fluids to maintain health. Malnutrition is a state of faulty or imperfect nutrition that is reflected in a combination of abnormal anthropometric and biochemical measures as established by the World Health Organization and reported in medical and nutritional literature by Jelliffe (1966), Blackburn et al. (1977), Klidjian et al. (1980), Chumlea (1984), Karkeck (1985), and Lipschitz (1986).

The nutritional status of each study subject was measured by anthropometric measurements (height, weight, and percent of ideal body weight) and biochemical assay reports (serum albumin). Using the guidelines for determining nutritional status outlined by the World Health Organization for weight and serum albumin, each person was classified as normally nourished if percent of ideal body weight was within 90 percent of standard and if serum albumin was above 3.5 mg/dl. Percent of ideal body weight and serum albumin were treated as two independent variables representing nutritional status. Percent of ideal body weight measuring inadequacy or excess of caloric intake, and serum albumin measuring protein status at the time of hospital admission. The person was classified as moderately malnourished if the percent of ideal body weight was 60 to 90 percent of ideal body weight, severely malnourished if below 60 percent of ideal body weight, and protein-calorie malnourished if the serum albumin was less than 3.5 mg/dl.
Personality Hardiness. Kobasa, Maddi, Puccetti and Zola (1985) define hardiness as a personality style consisting of the interrelatedness of commitment (versus alienation), control (versus powerlessness), and challenge (versus threat). People with high commitment easily involve themselves in whatever they are doing, are generally curious about events, people and activities (Maddi, Hoover, Kobasa, 1982). People with a high degrees of internal control express beliefs and act to influence the events around them through what they imagine or what they do (Phares, 1976). Challenge is the expectation of change and the personal development that will grow from it (Kobasa, Maddi, Puccetti, & Zola, 1985). In this study, the three scores for commitment, control, and challenge are added to form one personality hardiness score. The higher the score, the higher the degree of personality hardiness.

Social Support. Social support is broadly defined as the existence or availability of individuals on whom one can rely for love and assistance (Sarason, Levine, Basham, & Sarason, 1983). This study adopted definitions developed by Tilden, Nelson, and May (1990) which subdivided social support into two subsets of social support and conflict. Social support is the perceived availability or enactment of helping behaviors by members of the social network. Conflict is the perceived discord or stress in relationships caused by behaviors of others or the absence of behaviors of others such as the withholding of help.

Social support was measured by a twenty-six item tool (Appendix C) developed by Tilden, Nelson, and May (1989) (personal correspondence,
The Interpersonal Relationship Inventory Scoring Information (IPRI) survey consists of 26 Likert items, each scored from 1 to 5. Items yield two scores, one for support and one for conflict. Scale scores are derived by simple summation of item scores. Positive scores indicate increasing perceptions of social support. Negative scores reflect decreasing perceptions of social support. The sum of the two scales, social support and conflict, is the total social support score used in this study.

**Age.** Older adults are men or women aged 60 years or older. Age in years was noted as recorded on the hospital record at the time of admission.

**Sex.** Sex was listed as male or female for each subject.

**Ethnicity** was classified by an eighteen-item designation according to each person's classification on the hospital record.

**Severity of Illness.** Severity of illness or heart disease was defined as the left ventricular ejection fraction reported on the preoperative cardiac catheterization report by the attending cardiologist. The number of secondary diagnoses per patient was also recorded.

**Socioeconomic Status.** The level of education, as indicated on Tilden's demographic scale, served as the primary indicator of socioeconomic status. In addition, the type of health insurance was noted.
Procedure

Each patient referred to the study signed an informed consent giving permission to participate (Appendix E). A letter explaining the study was given to each candidate. Each subject completed a demographic profile (Appendix A), the personality hardiness test (Appendix C), and the social support measurement tool (Appendix D) with assistance of the principal investigator if needed. A nutritional assessment (Appendix B) was conducted by the principal investigator during the preoperative visit to the hospital. During the same visit, a blood sample for serum albumin was drawn with routine preoperative blood work from each subject by the hospital laboratory technician. The entire procedure took one hour.

Following admission to the hospital, the medical record of each patient was checked to determine age, ethnicity, health insurance, the left ventricular ejection fraction, the number of secondary diagnoses reported in the medical record, the number of postoperative ICU hours, the length of acute hospital stay, and the discharge status.

Instruments

Hospital Length of Stay (HLOS)

The number of days as recorded on the hospital record was noted. Days counted include from the first day after admission and the period up to and including the day of discharge from the hospital or the day the status is changed from acute care.
Number of Intensive Care Hours (ICUHRS)

The number of postoperative complications noted by physicians at discharge tends to vary by physician in final reports. Some episodes such as arrhythmias may be listed by some physicians and not by others although arrhythmias are documented in the medical record. Because of the inconsistencies or subjectivity of the list of complications, the number of postoperative ICUHRS was used as a more objective, quantifiable outcome variable which represented complications. The number of ICUHRS was noted from the hospital record and included the hour of admission through the hour of discharge. The number of ICUHRS is a good indicator of the number of complications experienced by the patient following surgery. The ICUHRS also indicates the amount of health care resources required to sustain a patient following surgery.

Demographic Data

Demographic information including sex, age, occupation or former occupation, level of education completed, marital status, and number of children were collected on each individual subject (Appendix A). Ethnicity was taken from the hospital record at the time of admission.

Nutritional Status

Percent of Ideal Body Weight and Albumin. Weight-for-height standards cited in Metropolitan Life Insurance Company tables (1983) are derived mathematically from "desirable" levels calculated by American insurance companies on the basis of a large-scale study of body build, blood pressure, and other factors affecting longevity (Jelliffe, 1966).
These highly-used tables have been revised (1983) and weight-for-height has increased since the first table was issued (1959). Optimal weight and body fat values associated with the lowest morbidity and mortality for the older adult are unknown. Research by Andres (1980) and Kohrs and Tobben (1982) indicates that optimal weight for elderly may be different than for younger individuals when mortality and morbidity are considered. Weight tables developed in 1983 Metropolitan Life Insurance tables were used to determine "normal-weight-for-height" in this study. Each subject, in light clothing without shoes, was measured for height in inches and weighed in pounds twice on a balance beam scale by the principal investigator. The subject's weight for height was compared to the medium point of the ideal body weight and a percent of ideal body weight was calculated. (Appendix B)

Protein status was measured by serum albumin levels and compared to the 3.5mg/dl standard.

**Personality Hardiness**

Hardiness was measured by a thirty-five-item scale, Hardiness in Aids Volunteers (Kobasa & Cassel, 1991) which was renamed the Hardiness Scale (Appendix C). This scale was developed by Kobasa’s Personal Views Survey (Hardiness Institute, Inc., Chicago, Ill., 1985) and consists of three subscales: commitment, control, and challenge. The hardiness score is a composite of the three scores added together.

The fifty-item Personal Views Survey (PVS) and the earlier surveys were conducted primarily on 670 middle and upper level male executives in a Chicago public utility (Kobasa, 1979), 157 general practice lawyers
(Kobasa, 1982), and 70 Chicago business men (Kobasa, Maddi, Puccetti, & Zola 1985). The PVS was modified to the Hardiness in Aids Volunteers (HAV) questionnaire primarily to avoid sexist language, to make the survey applicable for people who were not full-time employees, and to change questions about children and marriage to reflect involved relationships. The HAV tool has been tested on two volunteer samples—587 new volunteers and 225 veterans who had been volunteering for at least 18 months (personal correspondence, Kobasa, 1991). Kobasa concluded that the HAV scale was "...an adequate measure of personality hardiness, general enough to be used with AIDS volunteers and other adult samples in testing stress resilience models" (personal correspondence, Kobasa, 1991). A total hardiness score was computed by adding three standard scores for each subject.

Validity of the hardiness concept as a moderator in the stressful life event/illness relationship has been established empirically with a scale reliability (coefficient alpha) of .86 (Kobasa and Maddi, 1982). Lambert, Lambert, Klipple and Mewshaw (1990), using the 1984 scale, reported reliability for the total hardiness scale and the three subscales, commitment, control, and challenge as .72, .74, .62, and .51 respectively in a study of women with rheumatoid arthritis.

Social Support

Social support was measured by a 26-item tool (Appendix D) developed by Tilden, Nelson, and May (1989). The Interpersonal Relationship Inventory Scoring Information (IPRI) survey is a measure of interpersonal relationships which consists of 39 Likert items, each
scored from 1 to 5. This tool extends the usual measurement of social support to include the less often measured aspects of reciprocity and conflict. Scale scores (TOTSOC) are derived by simple summation of two (support and conflict) item scores where the items from the scales are mixed in order to avoid response sets.

Tilden and colleagues based the IPRI on the social exchange theory (Burgess & Huston, 1979; Cook, 1987) and equity theory (Messick & Cook, 1983) and contend that "...interpersonal relationships within social networks depend on reciprocal exchanges of emotional and tangible supplies. People consider the cost-benefit ratio of relationships and reciprocation is an implicit expectation."

Tilden, Nelson, and May (1990) reported a Cronbach's alpha internal consistency reliability coefficient of .92 for support, .83 for reciprocity, and .91 for conflict. A two-week test-retest stability reliability of the support scale was .91, of the reciprocity scale was .84, and of the conflict scale was .81. During psychometric testing the IPRI has been given to varied samples of adults including graduate and undergraduate students (n =105), cancer patients in health education classes (n =130), shelter residents (battered women, n = 30), community residents (n = 42), pregnant women (n = 30), and health maintenance organization subscribers (n = 531). Tilden, Nelson, and May (1990) reported that the IPRI "... demonstrated sufficient initial psychometric strength to warrant its continued evaluation in research with a wide variety of adult populations."

Although Tilden and colleagues found that all three subscales consistently demonstrated adequate internal consistency and reliability
throughout all phases of psychometric evaluations, other validity studies found the reciprocity score was not as strong psychometrically as the support and conflict scores (personal correspondence from Dr. Virginia Tilden, 1991). Therefore, the shorter form with the reciprocity subscale omitted was selected for the measurement of social support for this study.

Severity of Illness

Severity of Illness is difficult to quantify in older adults due to confounding illnesses. Patients in this age group seldom present with a single disease or problem. Additionally, the number of secondary diagnoses listed on the medical history results from the interviewer's individual skill and practice specialty. The secondary diagnoses and contributing risk factors typically include histories of smoking, myocardial infarctions (MI), hypertension, cerebral vascular accidents (CVA), diabetes, and prior open heart surgeries (OHS).

Severity of illness may also be quantified by the number of diseased vessels or the number of grafts done during the bypass operation. The more diseased vessels, the greater the severity of illness. Fewer vessels are grafted at time of surgery in women who have smaller vessels and also have a higher and earlier mortality rate than men (Gersh, Puga et al., 1981).

Valvular repair as well as bypass surgeries were included in this open heart surgery study. Because of the biases toward heart disease risk factors in medical histories and inconsistent histories of other conditions, a more objective measurement, the left ventricular ejection
fraction (EJFX), was adopted as an indicator for severity of illness for both types of procedures. Left ventricular EJFX is a very useful index of ventricular function. Ejection fraction is calculated by cineangiogram with injection of contrast medium into the left ventricle. Volume is determined by planimetry measurement of the left ventricle chamber area which estimates volume. The EJFX is equal to the end-diastolic volume (heart at rest) minus the end-systolic volume (after heart contraction) divided by the end-systolic volume. A normal EJFX of the left ventricle is 0.55 or greater. When the EJFX is reduced, the presence of depressed left ventricular function is suggested such as in congestive heart failure.

The selection of this variable was based on the work of Hannan et al. (1990), Mattila, Ventro, Ristikankare, and Mattila (1990), and Ko et al. (1991) who found that the EJFX was a predictor of operative mortality. Ko et al.'s (1991) method of quantifying EJFX was adopted in this study. All EJFXs were recorded as percentage or a rank (good, fair, or poor) on the cardiac catheterization record, the physician's admission history, or in the office record. Preoperative EJFX of greater than 50 percent (>50%) was considered good, fair if 30 to 50 percent (30% to 50%), and poor if less than 30 percent (<30%).

**Statistical Analysis**

Multiple linear regression was the statistical method used to determine the relationships of the independent (nutritional status, personality hardiness, and social support) and confounding variables (the left ventricular ejection fraction, age, sex, and level of
education) with the dependent variables, the number of intensive care hours and acute length of stay following non-emergent surgery.

Regression analysis is one of the most widely used statistical tools for analyzing multivariate data. It provides a conceptually simple method for investigating functional relationships among variables. The standard approach in regression analysis is to use a sample of data to compute an estimate of the proposed relationship, then evaluate the fit using statistics such as the t-test, F, and the R-Square (Chatterjee & Price, 1991).

Modern methods for subset model selection including Mallows’ Cp, Akaike’s AIC, and Allen’s Press were incorporated in data analysis. These methods were chosen rather than the conventional stepwise procedures which are widely used for subset selection. Hammer (1991), citing Beck (1978) and others, has recommended that stepwise procedures should be avoided in subset selection. The deficiencies of the one-variable-at-a-time methods have been criticized primarily because they fail to chose the best subset. The primary problems with stepwise selection is that (a) it implies an order of importance to the variables that may be confusing and misleading, and (b) in the case of early termination, the procedure may fail to detect important variables (Hocking, 1983, as cited by Hammer, 1991). Stepwise procedures do not optimize any reasonable criterion function for choosing a model.

Indeed, backward elimination and forward selection usually lead to different subsets of a given size. “There is no assurance that stepwise procedures will result in the best subset with regard to any standard dealing with theoretical sensibility, prediction performance, etc.”
(Myers, 1990). The use of stepwise procedures in statistical models proposed in medical and nutritional literature may explain why so many of the models have not produced expected results in different samples.

The primary purpose of regression analysis is to obtain a statistical model or models that best explain or predict the observed data. The two primary goals of model selection are to (1) select the most parsimonious (fewest variables) or "best" subset models and (2) select a one (representing the total sample) or two population (representing men and women separately) model for each dependent variable.

Sample size was determined using the Kleinbaum, Kupper, and Muller (1988) guidelines for specifying regression equations. The minimum requirement for regression is approximately 10 error degrees of freedom, namely, \( n - k - 1 \geq 10 \) (\( n \) is the number of observations and \( k \) the number of predictors) or \( n > 10 + k + 1 \). With 8 independent variables, the minimum number of subjects would be 19. Another guideline for sample size in regression models is at least 5 to 10 observations per predictor, namely, \( n \geq 5k \) (40 subjects) or \( n \geq 10k \) (80 subjects). This study was projected on at least 40 subjects.

The study data were analyzed on the mainframe computer using SAS statistical software, Version 5.18. Standard descriptive statistics including measures of central tendency and variability are reported for each of the interval or continuous variables in the one-population model and for the separate models for each sex. The full model for each group included: serum albumin, percent of ideal body weight, personality hardiness scores, social support scores, the left ventricular ejection
fraction, age, level of education, the number of intensive care hours postoperatively, and the acute hospital length of stay days. Correlations were run on all study variables in the full model and in the separate models for men and women.

Regression methods were used to estimate the equations for the entire data set and for separate data sets for men and women. The three statistical criteria used for subset selection—Mallows’ Cp (Mallows 1964; 1966; 1973), Allen’s PRESS (Allen, 1974), and Akaike’s AIC (1973; 1974) (Hammer, 1991)—are defined in the following text. Outlier detection was made through the use of graphic displays (partial regression plots), measures based on residuals (the hat matrix and studentized residuals), and measures that highlight influential observations (DFITS and DFBETAS) (Bollen & Jackman, 1985). An outlier or an extreme value may be statistically several standard deviations from the mean of the study data or substantively very different from the rest of the data set. The presence of such an extreme value can result in modification of the analysis or require further explanation. Outliers and influential cases should only be eliminated after careful examination.

**Selection Criteria**

*Mallows’ CP.* Mallows’ Cp is a procedure used for subset selection. The Cp models have low Cp values about equal to the number of parameters (p) estimated. The expected value of Cp is p + 1 when there is no bias. Sets of variables corresponding to points close to the Cp = p + 1 are good or desirable subsets. Biased models will appear
above (often considerably above) the $C_p = p + 1$ line (Hammer, 1991). The $C_p$ is not intended for the selection of a single best subset. Because the $C_p$ value can be less than $p + 1$, the minimum $C_p$ value will give bad results where a large number of subsets are contenders for the honor of best subset model. Instead, the $C_p$ is meant to be helpful in the examination of the structure of the data, and in the recognition of some of the ambiguities that pertain to the selection of single best model from a pool of alternative models (Myers, 1990).

**Akaike's AIC.** Akaike's AIC (an information criterion) selects the best subset models among alternative parametric models based on observed data (Hammer, 1991). The AIC best subsets have values within 1.00 of the minimum AIC value. Since the AIC assumes that the underlying joint probability distribution is normal, the minimum AIC and PRESS subsets will be identical when the data are normally distributed. A disagreement between the AIC and PRESS minimum values provides a simple way to diagnose the violation of normality.

Akaike's AIC statistic is currently the only simple procedure to use for evaluating a one versus a two population model. A two population model is a better statistical choice than the one population model if the minimum AIC values for the full model exceeds the sum of the minimum AIC values for each of the two populations. A difference of 2.00 or less is considered ambiguous (Hammer, 1991).

**Allen's PRESS.** Allen's PRESS is a nonparametric cross validation estimate of the prediction variance or expected square error (ESE) that may be used to simulate prediction (Hammer, 1991). Using a set of data with the first observation held aside, the remaining $n - 1$ observations
are used to fit the model. Then, the first observation is replaced, and the second observation is withheld with coefficients estimated again. Each observation is removed one at a time until the candidate model is fit n times. There are n validations in which the fitting sample for each is of size n - 1 (Myers, 1990). The deleted response is estimated each time the model is fit, resulting in the PRESS residuals which are the true prediction errors. The equation with the smallest PRESS value is always the best subset model.

The following models of independent variables were used to predict two dependent variables: acute hospital length of stay and number of intensive care hours following surgery. The hypotheses models are:

**Acute Hospital Length of Stay Model (HLOS)**

\[ \text{HLOS} = b_0 - b_1(\text{albumin}) \pm b_2(\text{percent of ideal body weight}) - b_3(\text{personality hardiness}) - b_4(\text{social support}) \pm b_5(\text{age}) \pm b_6(\text{ejection fraction}) \pm b_7(\text{educational level}) + b_8(\text{men}) \]

**Complications Model (ICUHRS)**

\[ \text{ICUHRS} = b_0 - b_1(\text{albumin}) \pm b_2(\text{percent of ideal body weight}) - b_3(\text{personality hardiness}) - b_4(\text{social support}) \pm b_5(\text{age}) \pm b_6(\text{ejection fraction}) \pm b_7(\text{educational level}) + b_8(\text{men}) \]

The data were also split into two groups and the models were estimated for men and women separately.

"Hat" Matrix \((2p/n)\). The diagonal elements of H (hat) matrix give the leverage exerted on \(Y\). The closer each case is to 0, the less
the case's leverage on $Y$. The sum of $h_{ii}$ (defined as the individual diagonal elements of the hat matrix) = $p$ or the number of variables in $X_i$. Observations with an $h_{ii}$ value greater than $2p/n$ ($n$ is the number of the sample size) in moderate sample sizes (if $p > 10$ and $n - p > 50$) or $3p/n$ in small samples have high leverage and require further evaluation (Bollen & Jackson, 1985).

**Studentized Residuals.** Because of differences in the variances of the sample residuals, it is useful to standardize the sample residuals ($e_i$). This helps to determine whether the residual is large relative to its variance. Belsley et al. (1980) recommend use of the studentized residuals (RSTUDENT) (Bollen & Jackson, 1985). The studentized residual is just one more part of the puzzle to identify outliers but it should not be used alone.

**Selecting Influential Outliers.** Outlying cases were first visually screened and listed from partial regression plots. Outliers are distinct from most of the data points in the sample (Bollen & Jackson, 1985). Further analysis should give the researcher insight as to which outliers are influential and deserve either further study, demand explanation, or indicate (as a last resort) withdrawal from the study (Figure 2). Influential cases or data points are observations that either by themselves or along with other observations have a "demonstrably larger impact on the calculated values of various estimates (coefficients, standard errors, t-values, etc.) than is the case for most of the other observations" (Belsley et al., 1980 quoted in Bollen & Jackman, 1985).
<table>
<thead>
<tr>
<th><strong>Diagnostics</strong></th>
<th><strong>Cutoff</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial Regression Plots</td>
<td>Based on visual inspection</td>
</tr>
<tr>
<td>Diagonal of the Hat Matrix ($h_{ii}$)</td>
<td>$2p/n$ (if $p&gt;10$ &amp; $n-p&gt;50$)</td>
</tr>
<tr>
<td></td>
<td>or $3p/n$ in small samples</td>
</tr>
<tr>
<td>Studentized Residuals ($e_i$)</td>
<td>$t$ distribution ($df = n - p - 1$)</td>
</tr>
</tbody>
</table>

*Adapted from Bollen and Jackman (1985)*

**Figure 2: Cutoff Criteria for Identifying Outlier & Influential Cases***
CHAPTER 4

RESULTS

Descriptive Analysis

Fifty-two patients (n = 52), 38 men and 14 women completed this prospective study. The ratio of 38 men to 14 women was roughly 3:1 which is typical of samples reported in the literature with more men than women undergoing open heart surgery (Gersh, Frye et al., 1981; Faro, et al., 1983; Myers et al., 1987; Hannan et al., 1990). The ages of the study subjects ranged from 60 to 82 years with an overall mean age of 69.51 (S.D. ± 5.35) years (Table 1).

Table 1

<table>
<thead>
<tr>
<th>Sex</th>
<th>Range</th>
<th>Mean ± S. D.</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 38)</td>
<td>(n = 14)</td>
<td>(n = 52)</td>
</tr>
<tr>
<td>Men</td>
<td>61 to 77 years</td>
<td>69.57 ± 5.78</td>
<td>68.50</td>
</tr>
<tr>
<td>Women</td>
<td>60 to 82 years</td>
<td>69.35 ± 5.00</td>
<td>68.50</td>
</tr>
<tr>
<td>Full Sample</td>
<td>60 to 82 years</td>
<td>69.51 ± 5.35</td>
<td>68.50</td>
</tr>
</tbody>
</table>

The mean ages of men and women were not significantly different (t = 0.0099, 50 df).

Ethnicity was noted according to the patient's statement at the time of admission to the hospital. Ten different categories from a possible 18 were indicated by the sample subjects (Table 2).
Table 2

Sample Subjects Ethnicity by Sex

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Men</th>
<th>Women</th>
<th>Full Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hawaiian</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Portuguese</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Caucasian</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Japanese</td>
<td>21</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>Chinese</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Hispanic</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Filipino</td>
<td>5</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Hawaiian &amp; Oriental</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hawaiian &amp; Other</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

The majority of the subjects (48%) were Japanese Americans; 21 of the 25 Japanese Americans were men. The next highest group was Caucasian with 6 subjects, 4 of whom were men. The remaining groups included one to five subjects each.

Level of education was used as an indicator of socioeconomic level. Using Tilden's categories, six levels were identified and are presented in Table 3.

Table 3

Educational Level

<table>
<thead>
<tr>
<th>Level</th>
<th>Men (n = 38)</th>
<th>Women (n = 14)</th>
<th>Full Sample (n=52)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 Grades 0–8</td>
<td>10</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>Level 2 Grades 9–11</td>
<td>6</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Level 3 High School</td>
<td>14</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>Level 4 Some College</td>
<td>5</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Level 5 College Grad</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Level 6 Post College</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
Over fifty-seven percent (57.9%) of the men had at least a high school education. Fifty percent (50%) of the women had a high school or more. There are no significant differences in the mean levels of education between men and women ($t = 0.0234$, 50 df).

All subjects were retired from full-time employment. Six men had part-time work that was different from the full-time employment prior to retirement. Eleven patients (21%) were not eligible for Medicare benefits but were covered by private insurance. Of the remaining 41 patients, all received Medicare benefits and had private supplemental insurance.

Nutritional status was measured by percent of ideal body weight (PIDBW) and level of serum albumin (ALB) in study subjects. Subjects within 10 percent of ideal body weight are considered normally nourished. Serum albumin of 3.5 milligrams per deciliter or above is considered within normal protein status. Percent of ideal body weight and serum albumin levels of study subjects are presented in Table 4. Women in the study tended to be heavier with lower serum albumin levels. However, there were no significant differences between the means of the percent of ideal body weight ($t = 1.56$, 50 df) in men and women or between the means of serum albumin ($t = 1.17$, 50 df).

Personality Hardiness was measured by Kabasa's thirty-five-item scale, Hardiness in Aids Volunteers (Kobasa & Cassel, 1991) which was titled Personality Hardiness Survey for the present study (Appendix B). All patients but one completed the survey. The three subscales were added together to form the personality hardiness score. The higher the
Table 4

Nutritional Status of Study Subjects

<table>
<thead>
<tr>
<th></th>
<th>Men (n = 38)</th>
<th>Women (n = 14)</th>
<th>Full Sample (n = 52)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIDBW Range</td>
<td>-41% to 28%</td>
<td>-9% to 68%</td>
<td>-41% to 68%</td>
</tr>
<tr>
<td>Mean + S. D.</td>
<td>6.9% ± 14.1%</td>
<td>14.7% ± 20.2%</td>
<td>9.1% ± 16.1%</td>
</tr>
<tr>
<td>Median ALB</td>
<td>11%</td>
<td>10%</td>
<td>11%</td>
</tr>
<tr>
<td>ALB Range</td>
<td>2.8 to 4.3</td>
<td>3 to 4.1</td>
<td>2.8 to 4.3</td>
</tr>
<tr>
<td>Median ALB Mean</td>
<td>3.76 ± 0.34</td>
<td>3.63 ± 0.38</td>
<td>3.72 ± 0.35</td>
</tr>
<tr>
<td>Median ALB</td>
<td>3.70</td>
<td>3.75</td>
<td>3.70</td>
</tr>
</tbody>
</table>

score the greater the personality hardiness. The full sample of men and women had a mean score of 20.77 (S.D. ± 26.30) personality hardiness score (Table 5). Women had a mean score of 24.64 (S. D. ± 22.93, range -22 to 58) and men had a mean score of 19.34 (S. D. ± 27.57, range -44 to 94). The personality hardiness group means for men and women were not significantly different (t = 0.69920, 49 df).

Table 5

Personality Hardiness of Sample Subjects

<table>
<thead>
<tr>
<th></th>
<th>Men (n = 37)*</th>
<th>Women (n = 14)</th>
<th>Full Sample (n = 51)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>-44 to 94</td>
<td>-22 to 58</td>
<td>-44 to 94</td>
</tr>
<tr>
<td>Mean ± S.D.</td>
<td>19.89 ± 27.38</td>
<td>24.64 ± 22.93</td>
<td>21.17 ± 26.13</td>
</tr>
<tr>
<td>Median</td>
<td>16.00</td>
<td>26.00</td>
<td>25.00</td>
</tr>
</tbody>
</table>

*One subject refused to complete the questionnaire.

Social support was measured by Tilden’s Interpersonal Relationship Inventory Short Form, consisting of 26 Likert items, which yield two scores, one for support and one for conflict. The scale score for each patient was derived by simple addition of the item scores into a total
score (Table 6). The higher the total score, the more the social
support. The mean social support score for the total sample was 17.27
(S. D. ± 10.54, range -10 to 45). Women had a mean score of 18.07 (S. D.
± 10.14, range -1 to 37); men had a mean score of 16.97 (S. D. ± 10.81
range -10 to 45). The mean scores for men and women were not
significantly different (t = 0.340557, 49 df).

Table 6

<table>
<thead>
<tr>
<th></th>
<th>Men (n = 37)</th>
<th>Women (n = 14)</th>
<th>Full Sample (n = 51)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Range</strong></td>
<td>- 10 to 45</td>
<td>- 1 to 37</td>
<td>- 10 to 45</td>
</tr>
<tr>
<td><strong>Mean ± S. D.</strong></td>
<td>16.97 ± 10.67</td>
<td>18.07 ± 10.14</td>
<td>16.94 ± 10.71</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>16.00</td>
<td>18.50</td>
<td>16.00</td>
</tr>
</tbody>
</table>

*One subject refused to complete the questionnaire.

The secondary diagnoses related to heart disease which were listed
at the time of the patient’s discharge from the hospital are presented
in Table 7.

Table 7

<table>
<thead>
<tr>
<th>Secondary Diagnoses</th>
<th>Men (n = 38)</th>
<th>Women (n = 14)</th>
<th>Full Sample (n = 52)</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of Smoking</td>
<td>12 (31.6%)</td>
<td>2 (14.3%)</td>
<td>14 (26.9%)</td>
</tr>
<tr>
<td>MI</td>
<td>12 (31.6%)</td>
<td>3 (21.4%)</td>
<td>15 (28.8%)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>29 (76.3%)</td>
<td>12 (85.7%)</td>
<td>41 (78.8%)</td>
</tr>
<tr>
<td>CVA</td>
<td>8 (21.1%)</td>
<td>3 (21.4%)</td>
<td>11 (21%)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>11 (28.9%)</td>
<td>8 (57.1%)</td>
<td>19 (36.5%)</td>
</tr>
<tr>
<td>Prior OHS</td>
<td>8 (21.1%)</td>
<td>2 (14.3%)</td>
<td>10 (19.2%)</td>
</tr>
</tbody>
</table>
Hypertension, the most prevalent secondary diagnosis, was present in 41 (78.8%) of the sample subjects with men and women having approximately equal frequencies of the disease. Diabetes, the next most prevalent secondary diagnosis, was present in 19 subjects (36.5%), and women (57.1%) were twice as likely to have the disease in this sample. Fifteen patients (28.8%) had histories of myocardial infarction with men more likely to have a history of infarction than women. Men were also more likely to have a history of smoking and a history of prior heart surgery. Cerebral vascular accident episodes were comparable between the two sexes. The number of secondary diagnoses in men ranged from 0 to 7 (Mean = 3.18, S. D. ± 1.83). Women as a group had a range from 2 to 5 secondary diagnoses per patient (Mean = 3.36, S.D. ± 1.22).

Left ventricular ejection fractions (EJFX), which are explained under Methodology, were used to quantify severity of illness or severity of heart disease prior to surgery. A normal ejection fraction of the left ventricle is 0.55 or greater. When the ejection fraction is reduced, the presence of depressed left ventricular function is suggested such as in congestive heart failure. Results are presented in Table 8.

<table>
<thead>
<tr>
<th>Left Ventricular Ejection Fractions in Men and Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>EJFX</td>
</tr>
<tr>
<td>Good (&gt;50%)</td>
</tr>
<tr>
<td>Fair (30% to 50%)</td>
</tr>
<tr>
<td>Poor (&lt;30%)</td>
</tr>
</tbody>
</table>
Treating the ejection fraction (EJFX) variable as an interval variable, the full sample mean = 1.37 (S. D. ± 0.60). The mean men’s ejection fraction (mean = 1.37, S. D. ± 0.63) compared to the women’s ejection fraction (mean = 1.36, S. D. ± .497) was not significantly different (t = 0.0526, 50 df).

The summary of descriptive statistics for the independent variables is presented in Table 9.

Table 9
Independent Variables in Full Sample (n=52)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Box Plot</th>
<th>Mean</th>
<th>Median</th>
<th>S.D.</th>
<th>Max</th>
<th>Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personality Hardiness</td>
<td>Normal</td>
<td>21.176</td>
<td>25.00</td>
<td>26.3</td>
<td>94.00</td>
<td>-44.00</td>
</tr>
<tr>
<td>Total Social Support</td>
<td>Normal</td>
<td>17.274</td>
<td>16.00</td>
<td>10.5</td>
<td>45.00</td>
<td>-10.00</td>
</tr>
<tr>
<td>% Ideal Body Weight</td>
<td>Normal</td>
<td>00.090</td>
<td>00.11</td>
<td>0.16</td>
<td>00.68</td>
<td>-0.41</td>
</tr>
<tr>
<td>Albumin</td>
<td>Normal</td>
<td>03.720</td>
<td>03.70</td>
<td>0.35</td>
<td>04.30</td>
<td>2.80</td>
</tr>
<tr>
<td>Age</td>
<td>Normal</td>
<td>69.780</td>
<td>69.00</td>
<td>5.56</td>
<td>82.00</td>
<td>60.00</td>
</tr>
<tr>
<td>Education*</td>
<td>Negative Skew</td>
<td>02.630</td>
<td>03.00</td>
<td>1.31</td>
<td>06.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Ejection Fraction*</td>
<td>Negative Skew</td>
<td>01.360</td>
<td>01.00</td>
<td>0.595</td>
<td>03.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Sex</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

*Rank data treated as interval
NA = Not applicable

Distributions of both dependent variables are negatively skewed on visual examination of the bar graphs and the box plots. Acute hospital length of stay (HLOS) is one of the two dependent study variables (Table 10). There was no significant difference between the means of men and women’s acute hospital length of stay (t = 0.0348, 50 df).
Table 10

Acute Hospital Length of Stay Following Open Heart Surgery

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
<th>Full Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n = 38)</td>
<td>(n = 14)</td>
<td>(n = 52)</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>2 to 51</td>
<td>0 to 53</td>
<td>0 to 53</td>
</tr>
<tr>
<td>Mean ± S. D.</td>
<td>11.45 ± 10.16</td>
<td>11.57 ± 12.42</td>
<td>11.48 ± 10.69</td>
</tr>
<tr>
<td>Median</td>
<td>8.00</td>
<td>8.50</td>
<td>8.00</td>
</tr>
</tbody>
</table>

The number of hours spent in the intensive care unit of the hospital (ICUHRS) was used as a quantifiable measure of postoperative complications. Consensus among cardiac surgeons indicated that anything over 48 hours is generally accepted as abnormal and indicates cardiovascular, respiratory, or infectious complications. There was a significant difference (p < 0.005) between the ICUHRS mean of men and ICUHRS of women (t = 5.656, 50 df) indicating that women have more complications following open heart surgery than men.

Table 11

Number of Intensive Care Hours Following Open Heart Surgery

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
<th>Full Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n = 38)</td>
<td>(n = 14)</td>
<td>(n = 52)</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>26.50 to 336.00</td>
<td>4.0 to 182.50</td>
<td>4 to 336</td>
</tr>
<tr>
<td>Mean ± S. D.</td>
<td>62.5* ± 51.28</td>
<td>75.38* ± 50.45</td>
<td>65.96 ± 50.45</td>
</tr>
<tr>
<td>Median</td>
<td>48.25</td>
<td>65.96</td>
<td>49.00</td>
</tr>
<tr>
<td>&lt; 48 HRS ICU</td>
<td>19</td>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td>&gt;48 HRS ICU</td>
<td>19</td>
<td>8</td>
<td>27</td>
</tr>
</tbody>
</table>

* t = 5.656, 50 df
p < 0.005

Death following surgery was treated independently. Two of the 14 women died during the hospitalization period immediately following
surgery (mortality rate of 14.3%), and one of the 38 men died during the same time frame (mortality rate of 2.6%). The death rate was examined at 30, 60, and 90 days following surgery (Table 12).

Table 12
Deaths Within 30 days, 60 days, and 90 days of Surgery

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
<th>Full Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cum. freq. (%)</td>
<td>cum. freq. (%)</td>
<td>cum. freq. (%)</td>
</tr>
<tr>
<td>During HLOS</td>
<td>1 (2.6%)+</td>
<td>2 (14.3%)+</td>
<td>3 (5.7%)</td>
</tr>
<tr>
<td>Within 30 days</td>
<td>2 (5.3%)</td>
<td>2 (14.3%)</td>
<td>4 (7.6%)</td>
</tr>
<tr>
<td>Within 60 days</td>
<td>3 (7.8%)</td>
<td>2 (14.3%)</td>
<td>5 (9.6%)</td>
</tr>
<tr>
<td>Within 90 days</td>
<td>4 (10.5%)*</td>
<td>2 (14.3%)*</td>
<td>6 (11.5%)</td>
</tr>
</tbody>
</table>

+chi square = 2.55, NS
*chi square = 0.140, NS

Six patients or 11.5 percent of the total sample died within 90 days of open heart surgery. Women had a higher mortality rate during hospitalization and overall (14.3%). Although men had a much lower mortality rate during the initial hospitalization following open heart surgery (2.6%), their mortality rate increased to 10.5 percent within 90 days following surgery. The difference between deaths in men and women during hospitalization or 90 days postoperatively was not statistically significant.

The differences between the numbers of men and women who died were not statistically different from each other, from their respective samples, nor the total sample. The men who died, however, were older, had higher personality hardiness scores, had more social support than the two women who died. The women, on the other hand, had higher percentage of body weight than the men.
Table 13

Independent Variables in Patients Who Died Following Open Heart Surgery

<table>
<thead>
<tr>
<th>Variables</th>
<th>Men (n = 4)</th>
<th>Women (n = 2)</th>
<th>All Deaths (n = 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>%IDBW</td>
<td>6.75% ± 14%</td>
<td>45% ± 33%</td>
<td>19.5 ± 26.8</td>
</tr>
<tr>
<td>ALB</td>
<td>3.87 ± 0.40</td>
<td>3.60 ± 0.71</td>
<td>3.78 ± 0.47</td>
</tr>
<tr>
<td>Pershard</td>
<td>29.25 ± 23.08</td>
<td>5.5 ± 27.58</td>
<td>21.33 ± 24.94</td>
</tr>
<tr>
<td>Social Support</td>
<td>18.25 ± 13.67</td>
<td>2.5 ± 4.95</td>
<td>13.00 ± 13.54</td>
</tr>
<tr>
<td>AGE</td>
<td>76.75 ± 5.12</td>
<td>69.00 ± 9.90</td>
<td>74.17 ± 7.17</td>
</tr>
<tr>
<td>EJFX</td>
<td>1.25 ± 0.50</td>
<td>1.5 ± 0.71</td>
<td>1.33 ± 0.52</td>
</tr>
<tr>
<td>ED</td>
<td>2.75 ± 1.26</td>
<td>4.5 ± 2.12</td>
<td>3.33 ± 1.63</td>
</tr>
</tbody>
</table>

Bivariate Analysis

Correlation of the study variables are represented in Table 14.

Table 14

Correlation of Study Variables in Total Sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>ALB</th>
<th>PIDBW</th>
<th>PERHARD</th>
<th>TOTSOC</th>
<th>AGE</th>
<th>EJFX</th>
<th>ED</th>
<th>ICUHRS</th>
<th>HLOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALB</td>
<td>1.0000</td>
<td>-0.1650</td>
<td>-0.0193</td>
<td>-0.0240</td>
<td>-0.2508</td>
<td>0.0546</td>
<td>-0.0626</td>
<td>-0.0555</td>
<td>-0.3489</td>
</tr>
<tr>
<td>PIDBW</td>
<td>-0.1650</td>
<td>1.0000</td>
<td>0.1885</td>
<td>0.1536</td>
<td>-0.2519</td>
<td>-0.1023</td>
<td>0.1147</td>
<td>0.1069</td>
<td>0.1774</td>
</tr>
<tr>
<td>PERHARD</td>
<td>-0.0193</td>
<td>0.1885</td>
<td>1.0000</td>
<td>0.9847</td>
<td>0.0094</td>
<td>-0.1850</td>
<td>0.1424</td>
<td>0.0396</td>
<td>0.0299</td>
</tr>
<tr>
<td>TOTSOC</td>
<td>-0.0240</td>
<td>0.1536</td>
<td>0.9847</td>
<td>1.0000</td>
<td>0.0853</td>
<td>-0.1448</td>
<td>0.0639</td>
<td>0.1904</td>
<td>0.0759</td>
</tr>
<tr>
<td>AGE</td>
<td>-0.2508</td>
<td>-0.2519</td>
<td>0.0094</td>
<td>0.0853</td>
<td>1.0000</td>
<td>-0.0409</td>
<td>-0.2483</td>
<td>0.2453</td>
<td>0.1051</td>
</tr>
<tr>
<td>EJFX</td>
<td>0.0546</td>
<td>-0.1023</td>
<td>-0.1850</td>
<td>-0.1448</td>
<td>-0.0409</td>
<td>1.0000</td>
<td>-0.3024</td>
<td>0.3941</td>
<td>0.0520</td>
</tr>
<tr>
<td>ED</td>
<td>-0.0626</td>
<td>0.1147</td>
<td>0.1424</td>
<td>0.0639</td>
<td>-0.2483</td>
<td>-0.3024</td>
<td>1.0000</td>
<td>-0.2080</td>
<td>0.0770</td>
</tr>
<tr>
<td>ICUHRS</td>
<td>-0.0555</td>
<td>0.1069</td>
<td>0.0396</td>
<td>0.1094</td>
<td>0.2453</td>
<td>0.3941</td>
<td>-0.2080</td>
<td>1.0000</td>
<td>0.3436</td>
</tr>
<tr>
<td>HLOS</td>
<td>-0.3489</td>
<td>0.1774</td>
<td>0.0299</td>
<td>0.0759</td>
<td>0.1051</td>
<td>0.0520</td>
<td>0.0770</td>
<td>0.3436</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

Examination of the bivariate correlations for the total sample (combined men and women samples) revealed expected and unexpected relationships. An association between HLOS and serum albumin levels has been reported in medical-nutritional literature. In this study, serum albumin levels were negatively related to HLOS in the total sample as
expected \((r = -0.3489, \text{NS})\) but had very little relationship to number of postoperative intensive care hours \((r = 0.0555, \text{NS})\). Serum albumin levels were also negatively related to age \((r = -0.2508, \text{NS})\) which is consistent with the literature. Percent of ideal body weight was negatively related to age \((r = -0.1650, \text{NS})\) and may be explained by undetected cardiovascular fluid imbalances.

Personality hardiness (PH) was strongly related to social support \((r = 0.9847, p = 0.0001)\) in the total sample.

Age was negatively correlated with education \((r = -0.2483, \text{NS})\) and percent of ideal body weight \((r = -0.2519, \text{NS})\). The negative correlation between age and the level of education and age and the percent of ideal body weight were expected. Age was positively related to the number of postoperative intensive care hours (postoperative complications) \((r = 0.2453, \text{NS})\) and very slightly related to acute hospital length of stay \((r = 0.1051, \text{NS})\) as expected.

Left ventricular ejection fraction (EJFX) was positively related to number of intensive care hours postoperatively \((r = 0.3941, p = 0.0038)\). However, there was almost no correlation with acute hospital length of stay \((r = 0.0520, \text{NS})\). EJFX was also negatively related to education \((r = -0.3024)\).

The total sample was split on the sex variable and correlation within the two groups (Table 15: men and Table 16: women) was further examined and compared with the total sample. Two outlier cases were identified using Bollen and Jackman's criteria (1985). Both cases were women. One woman died on the day of surgery and the second, a very obese woman, suffered a myocardial infarction and had a prolonged
hospitalization. Correlation in the total sample without outlier cases and in the women's sample without outlier cases are displayed in Tables 17 and 18.

Table 15
Correlation of Study Variables in Men's Sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>ALB</th>
<th>PIDBW</th>
<th>PERHARD</th>
<th>TOTSOC</th>
<th>AGE</th>
<th>EJFX</th>
<th>ED</th>
<th>ICUHRS</th>
<th>HLOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALB</td>
<td>1.0000</td>
<td>-0.1417</td>
<td>0.0124</td>
<td>-0.0137</td>
<td>-0.2267</td>
<td>0.0190</td>
<td>-0.0395</td>
<td>-0.1254</td>
<td>-0.3261</td>
</tr>
<tr>
<td>PIDBW</td>
<td>-0.1417</td>
<td>1.0000</td>
<td>0.2518</td>
<td>0.2045</td>
<td>-0.1653</td>
<td>-0.1472</td>
<td>0.0127</td>
<td>-0.1736</td>
<td>0.0701</td>
</tr>
<tr>
<td>PERHARD</td>
<td>0.0124</td>
<td>0.2518</td>
<td>1.0000</td>
<td>0.9874</td>
<td>0.0202</td>
<td>-0.2001</td>
<td>0.1708</td>
<td>0.0499</td>
<td>0.0356</td>
</tr>
<tr>
<td>TOTSOC</td>
<td>-0.0137</td>
<td>0.2045</td>
<td>0.9874</td>
<td>1.0000</td>
<td>0.0952</td>
<td>-0.1642</td>
<td>0.0840</td>
<td>1.1232</td>
<td>0.0943</td>
</tr>
<tr>
<td>AGE</td>
<td>-0.2267</td>
<td>-0.1653</td>
<td>0.0202</td>
<td>1.0000</td>
<td>-0.0820</td>
<td>-0.2829</td>
<td>0.4406</td>
<td>0.2301</td>
<td></td>
</tr>
<tr>
<td>EJFX</td>
<td>0.0190</td>
<td>-0.1472</td>
<td>-0.2001</td>
<td>-0.1642</td>
<td>-0.0820</td>
<td>1.0000</td>
<td>-0.2568</td>
<td>0.4657</td>
<td>0.1165</td>
</tr>
<tr>
<td>ED</td>
<td>-0.0395</td>
<td>0.0127</td>
<td>0.1708</td>
<td>0.0840</td>
<td>-0.2829</td>
<td>1.0000</td>
<td>-0.3073</td>
<td>0.0414</td>
<td></td>
</tr>
<tr>
<td>ICUHRS</td>
<td>-0.1254</td>
<td>-0.1736</td>
<td>0.0499</td>
<td>0.1232</td>
<td>0.4406</td>
<td>0.4657</td>
<td>1.0000</td>
<td>0.2788</td>
<td></td>
</tr>
<tr>
<td>HLOS</td>
<td>-0.3261</td>
<td>0.0701</td>
<td>0.0356</td>
<td>0.0943</td>
<td>0.2301</td>
<td>0.1165</td>
<td>0.0414</td>
<td>1.0000</td>
<td></td>
</tr>
</tbody>
</table>

Albumin was negatively related to age in men \( (r = -0.2267, \ NS) \) and women \( (r = -0.3520, \ NS) \) This may indicate a tendency toward an increasing risk of protein-calorie malnutrition as heart patients become older.
The percent of ideal body weight (PIDBW) variable had stronger relationship to other study variables in the women’s sample than in the men’s. In men, the percent of ideal body weight was slightly related to HLOS ($r = 0.0701$, NS) and ICUHRS ($r = -0.1736$, NS). In women, percent of ideal body weight (PIDBW) was moderately associated with HLOS ($r = 0.3611$, NS) and strongly related with ICUHRS ($r = 0.6301$, $p = 0.0157$). When two outlier cases were removed from the women’s sample (Table 18), the association between PIDBW and HLOS was very close to the men’s correlation ($r = 0.0789$, NS), but the relationship to ICUHRS remained strong ($r = 0.6925$, $p = 0.0126$). Percent of ideal body weight in men was not significantly related to any other study variable. In women (without outliers), PIDBW was significantly related to age ($r = -0.5706$, $p = 0.0527$).

Table 17

Correlation of Study Variables in Total Sample Without Outlier Cases

<table>
<thead>
<tr>
<th>Variable</th>
<th>ALB</th>
<th>PIDBW</th>
<th>PERHARD</th>
<th>TOTSOC</th>
<th>AGE</th>
<th>EJFx</th>
<th>ED</th>
<th>ICUHRS</th>
<th>HLOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALB</td>
<td>1.000</td>
<td>-0.0581</td>
<td>-0.0090</td>
<td>-0.0189</td>
<td>-0.2505</td>
<td>0.0075</td>
<td>0.0864</td>
<td>-0.0336</td>
<td>-0.2973</td>
</tr>
<tr>
<td>PIDBW</td>
<td>-0.0581</td>
<td>1.0000</td>
<td>0.1904</td>
<td>0.1559</td>
<td>-0.2704</td>
<td>-0.0707</td>
<td>0.0331</td>
<td>0.0641</td>
<td>0.0456</td>
</tr>
<tr>
<td>PERHARD</td>
<td>-0.0090</td>
<td>0.1904</td>
<td>1.0000</td>
<td>0.9848</td>
<td>0.0067</td>
<td>-0.1829</td>
<td>0.1429</td>
<td>0.0413</td>
<td>0.0288</td>
</tr>
<tr>
<td>TOTSOC</td>
<td>-0.0189</td>
<td>0.1559</td>
<td>0.9848</td>
<td>1.0000</td>
<td>0.0862</td>
<td>-0.1438</td>
<td>0.0636</td>
<td>0.1121</td>
<td>0.0835</td>
</tr>
<tr>
<td>AGE</td>
<td>-0.2505</td>
<td>-0.2704</td>
<td>0.0067</td>
<td>0.0862</td>
<td>1.0000</td>
<td>-0.0327</td>
<td>-0.3303</td>
<td>0.3063</td>
<td>0.2019</td>
</tr>
<tr>
<td>EJFx</td>
<td>0.0075</td>
<td>-0.0707</td>
<td>-0.1829</td>
<td>-0.1438</td>
<td>-0.0327</td>
<td>1.0000</td>
<td>-0.2821</td>
<td>0.4213</td>
<td>0.1067</td>
</tr>
<tr>
<td>ED</td>
<td>0.0864</td>
<td>0.0331</td>
<td>0.1429</td>
<td>0.0636</td>
<td>-0.3303</td>
<td>-0.2821</td>
<td>1.0000</td>
<td>-0.2062</td>
<td>0.0632</td>
</tr>
<tr>
<td>ICUHRS</td>
<td>-0.0336</td>
<td>0.0641</td>
<td>0.0413</td>
<td>0.0021</td>
<td>0.3063</td>
<td>0.4213</td>
<td>-0.2062</td>
<td>1.0000</td>
<td>0.2397</td>
</tr>
<tr>
<td>HLOS</td>
<td>-0.2973</td>
<td>0.0456</td>
<td>0.0288</td>
<td>0.0835</td>
<td>0.2019</td>
<td>0.1067</td>
<td>0.0632</td>
<td>0.2397</td>
<td>1.0000</td>
</tr>
</tbody>
</table>
The personality hardiness score was strongly, positively correlated with social support \((r = 0.9847, p = 0.0001)\) in men. Personality hardiness is moderately related to social support in women \((r = 0.3868, \text{NS})\). This variable was stronger in women with a negative relationship to ICUHRS \((r = -0.3693, \text{NS})\) and PIDBW \((r = -0.3614, \text{NS})\). The relationship between PH and ICUHRS in the women's model became stronger when the two outlier cases were removed \((r = -0.4207, \text{NS})\) but were not significant.

Social support scores in men displayed weak correlation. Positive correlation was found with PH and with PIDBW \((r = 0.2045, \text{NS})\). Women (without outliers), on the other hand, had statistically significant negative correlation with ICUHRS \((r = -0.6240, p = 0.0301)\) and PIDBW \((r = -0.7488, p = 0.0051)\).

Ejection fractions (EJFX) in men were not strongly nor significantly related to other independent or dependent variables.
Women's ejection fractions (without two outlier cases) were moderately and significantly related to ICUHRS ($r = 0.4213$, $p = 0.0023$).

Education in men was negatively related to ICUHRS ($r = -0.3073$, NS) but positively related in women ($r = 0.4216$, NS). Education was negatively related to age in both men ($r = -0.2829$, NS) and women ($r = -0.1459$, NS) with the women's relationship (without outlier cases) more dramatic ($r = -0.6416$, $p = 0.0245$) and significant.

**Summary of Independent Variable Correlation with Outcome Variables**

In summary, the outcome variable HLOS was significantly, positively related to ICUHRS ($r = 0.3438$, $p = 0.0126$) and significantly, negatively related to ALB ($r = -0.3489$, $p = 0.0112$). In addition to the positive, significant relationship to HLOS, the second outcome variable ICUHRS was significantly and positively related to EJFX ($r = 0.3941$, $p = 0.0038$). When two outlier women subjects were removed from the combined sample, the HLOS was still significantly and negatively related to ALB ($r = 0.2973$, $p = 0.0360$), but no longer significantly related to ICUHRS. The ICUHRS was significantly and positively related to AGE ($r = 0.3063$, $p = 0.0305$) and EJFX ($r = 0.4213$, $p = 0.0023$).

In the men's sample, HLOS was significantly and negatively related to ALB ($r = -0.3261$, $p = 0.0457$). ICUHRS was significantly and positively related to AGE ($r = 0.4406$, $p = 0.0056$) and to EJFX ($r = 0.4657$, $p = 0.0032$). In the women's sample only PIDBW was significantly and positively related to ICUHRS ($r = 0.6301$, $p = 0.0157$). When the two outliers were removed from the women's sample, however, HLOS was still
significantly related to PIDBW ($r = 0.6925, p = 0.0126$) and TOTSOC ($r = -0.6240, p = 0.0301$).

**Multivariate Analysis**

The independent variables (ALB, PIDBW, PERSHARD, TOTSOC, AGE, EJFX, ED) comprising the full multiple regression model were used to predict: (1) number of hours spent in the intensive care unit postoperatively (ICUHRS) and (2) the acute hospital length of stay (HLOS). The HLOS variable is a frequent indicator in medical literature of how well a particular medical service is provided within a given health care facility. The number of complications, measured by the number of ICUHRS, following a surgical procedure also gives an indication of how well a procedure or a service is rendered to a given group of patients. The number of complications following surgery can prolong acute hospitalization. Although related, the two outcome variables (HLOS and ICUHRS) may have very different contributing factors. As a result, any indicators which impact either length of stay or complication rates are of intense interest to clinicians and administrators.

From the two one-population regression models with the dependent variables HLOS and ICUHRS, six subset models were selected which best represented the data: Two one-population (combined men and women) models for each outcome variable and four two-population models for men and women. The following text explains the procedure for model development and subset model selection using Akaike's AIC, Allen's PRESS, and Mallows' Cp statistical procedures.
One-Population Full Model of HLOS Following Open Heart Surgery (n = 52) (1)

Men:
HLOS = (41.635 + 1.69) - 9.57ALB + 13.42PIDBW - 0.16PERSHARD + 0.24TOTSOC + 0.05AGE + 1.12EJFX + 1.79ED

Women:
HLOS = 41.635 - 9.57ALB + 13.42PIDBW - 0.16PERSHARD + 0.24TOTSOC + 0.05AGE + 1.12EJFX + 1.79ED

p value (0.03) ALB (0.18) PIDBW (0.02) PERSHARD
(0.12) TOTSOC (0.86) AGE (0.67) EJFX (0.16) ED

Std Est. HLOS = - 0.32ALB + 0.20PIDBW - 0.40 PERSHARD + 0.24TOTSOC + 0.03AGE + 0.06 EJFX + 0.22 ED

R-square = 0.2640
Adjusted R-square = 0.1238
p = 0.0884

The full model for the one population (combined men and women) predicted 26.4 percent (adjusted R-square 0.1238) of the variance of acute hospital length of stay and was not statistically significant (p = 0.0884). The standardized estimate (std. est.) standardizes the parameters with an intercept of 0, allowing for each variable to be evaluated for its contribution to the overall model. The strongest variable in the equation is personality hardiness (std. est. = -0.40).

Akaike’s AIC, Mallows’ Cp, and Allen’s PRESS statistics were used to select the best subset models from the full model (Table 19).

<table>
<thead>
<tr>
<th>Model</th>
<th>R2</th>
<th>ADJ R2</th>
<th>p</th>
<th>AIC</th>
<th>CP</th>
<th>PRESS</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1217</td>
<td>0.104</td>
<td>0.1120</td>
<td>238.7780</td>
<td>3.2</td>
<td>5690.7863</td>
<td>ALB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.1656</td>
<td>0.131</td>
<td>0.0117</td>
<td>238.1219</td>
<td>2.2</td>
<td>5587.6175</td>
<td>ALB</td>
<td>PH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.1894</td>
<td>0.137</td>
<td>0.0164</td>
<td>238.6475</td>
<td>3.3</td>
<td>5965.2298</td>
<td>ALB</td>
<td>PH</td>
<td>ED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.1868</td>
<td>0.135</td>
<td>0.0170</td>
<td>238.8101</td>
<td>3.4</td>
<td>5805.3348</td>
<td>ALB</td>
<td>PH</td>
<td>ED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.1859</td>
<td>0.134</td>
<td>0.0171</td>
<td>238.8651</td>
<td>3.5</td>
<td>5571.7060</td>
<td>ALB</td>
<td>PH</td>
<td>TOTSOC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.2212</td>
<td>0.154</td>
<td>0.0156</td>
<td>238.6067</td>
<td>3.4</td>
<td>5831.5346</td>
<td>ALB</td>
<td>PH</td>
<td>ED</td>
<td>TOTSOC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0.2192</td>
<td>0.151</td>
<td>0.0165</td>
<td>238.7348</td>
<td>3.6</td>
<td>5654.6207</td>
<td>ALB</td>
<td>PH</td>
<td>PIDBW</td>
<td>TOTSOC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0.2550</td>
<td>0.178</td>
<td>0.0147</td>
<td>238.3406</td>
<td>3.5</td>
<td>5947.5901</td>
<td>ALB</td>
<td>PH</td>
<td>ED</td>
<td>PIDBW</td>
<td>TOTSOC</td>
<td></td>
</tr>
</tbody>
</table>
Eight subset models were selected using AIC scores within 1 of the minimum AIC number. Subset model number 2 using the independent variables albumin and personality hardiness seemed to be the strongest predictor model with a $p = 0.0117$ and R-square of .1656 (Adjusted R square = .131). The models were then analyzed again using Allen’s PRESS.

The three-variable subset (equation #5) with the lowest Allen’s PRESS value (5571.7060) is selected as the "best" model to represent the total sample ($n = 52$). The model is statistically significant ($p = 0.0171$), with a coefficient of determination of 0.1859, and the adjusted R-Square of 0.134.

One Population "Best" Subset Model of HLOS (2)

HLOS = 49.75 - 10.36ALB - 0.10PERSHARD + 0.15TOTSOC

(p value) (0.01)ALB (0.07)PERSHARD (0.28)TOTSOC

Std.E. HLOS = -0.34ALB - 0.26PERSHARD + 0.14TOTSOC

R-Square = 0.1859
Adj. R-Square = 0.134
p = 0.0171

The strongest variable in the equation is ALB (std. est. = -0.34) which agrees with reports in the medical literature and contributes to the outcome in the expected direction. Personality hardiness also is negatively related to HLOS, but TOTSOC, unexpectedly, is positively related.

Using Bollen and Jackman (1985) criteria for outliers, cases 43 (who died on the day of surgery) and 47 (an obese women who suffered an myocardial infarction and had a HLOS of 53 days) were selected as the
potentially most influential observations from four contenders in the total sample. Table 20 lists the potential outlier cases and the statistical values that were determined to be influential in the regression. These cases were also indicated on partial regression plots.

### Table 20

<table>
<thead>
<tr>
<th>CASE NUMBER</th>
<th>RSTUDENT</th>
<th>HAT</th>
<th>DFITS</th>
<th>AGE</th>
<th>EJFX</th>
<th>ALB</th>
<th>ED</th>
<th>PERSHARD</th>
<th>TOTSOC</th>
<th>PIDBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>3.4695</td>
<td>1.6711</td>
<td>0.5576</td>
<td>0.6025</td>
<td>0.4035</td>
<td>0.9438</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>2.4921</td>
<td>0.9885</td>
<td>0.3617</td>
<td>0.3520</td>
<td>0.2920</td>
<td>0.3316</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>2.5331</td>
<td>1.6893</td>
<td>0.6300</td>
<td>0.3061</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>3.8410</td>
<td>1.9918</td>
<td>0.3638</td>
<td>0.5112</td>
<td>0.5544</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CUTOFFS: 2.0000 0.4038 0.7844
DFBETAS CUTOFF: 0.2774 0.2774 0.2774 0.2774 0.2774 0.2774 0.2774

Case 43 was a 76-year-old Japanese-American woman, who was 22 percent above her ideal body weight with an ejection fraction of 68 percent (good), secondary diagnoses of hypertension and diabetes, and a serum albumin of 3.1 mg/dl. She underwent coronary artery bypass (CABG) surgery for 5 vessels and died within four hours of surgery. Case 47 was also a women who was 67 years of age and had a 51 percent ejection fraction (good) but who suffered a myocardial infarction during hospitalization. This patient had a prior history of myocardial infarction, diabetes and hypertension. Her serum albumin was only 3.0 and her body weight was 42 percent over ideal body weight on admission to the study. This patient had two coronary bypass grafts. Each of the above two cases skewed the data, one by having an abbreviated hospital length of stay and very few intensive care hours due to death, the
second by having extended stays due to a complication not experienced in
the rest of the sample. Therefore, both cases were substantively
determined to be influential cases and deleted from the total sample and
the women's sample for further study.

Deleting Cases 43 and 47 from the data set (n = 50) yielded the
following full HLOS model (Equation 3). Changes in the parameter
estimates (Equation 3) are compared to parameters of Equation 1 in Table
21.

One Population Full HLOS Model Without (W/O)
Outliers (3)

Men:
HLOS = (15.67 + 1.98) - 7.33ALB + 8.75PIDBW - 0.13PERSHARD +
0.19TOTSOC + 0.17AGE + 1.88EJFX + 2.27ED

Women:
HLOS = 15.67 - 7.33ALB + 8.75PIDBW - 0.13PERSHARD +
0.19TOTSOC + 0.17AGE + 1.88EJFX + 2.27ED

(p value) (ALB (0.31)PIDBW (0.03)PERSHARD
(0.13)TOTSOC (0.54)AGE (0.39)EJFX (0.06)ED

Std. Est. HLOS = -0.27ALB + 0.15PIDBW - 0.40PERSHARD + 0.23
TOTSOC + 0.10 AGE + 0.13 EJFX + 0.31ED

R-Square = 0.2748
Adj. R-square = .1297
p = 0.0880

The one population full model (combined men and women) without
outliers predicted 27.5 percent (adjusted R-square = 0.1297) of the
variance in acute hospital length of stay and was not statistically
significant (p = 0.0880). The strongest variable in the equation is
still personality hardiness (std. est. -0.40) which is negatively
associated with the outcome variable as expected. Albumin is also
negatively related, as expected, to the outcome variable. Education, an
indicator of socioeconomic status, was unexpectedly positively associated with length of stay and was second only to personality hardiness in its strength in the equation. The total social support variable did not perform as expected as it was positively related to length of stay. Age and ejection fraction were positively associated as expected. Older patients with failing hearts usually have longer hospitalizations.

**Table 21**


<table>
<thead>
<tr>
<th></th>
<th>Full Model (n = 52)</th>
<th>Full Model W/O Outliers (n = 50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>41.64 (1.26)</td>
<td>15.67 (0.55)</td>
</tr>
<tr>
<td>ALB</td>
<td>-9.57 (-2.22)</td>
<td>-7.33 (-1.94)</td>
</tr>
<tr>
<td>PIDBW</td>
<td>13.42 (1.36)</td>
<td>8.75 (1.03)</td>
</tr>
<tr>
<td>PERSHARD</td>
<td>-0.16 (-2.31)</td>
<td>-0.13 (-2.27)</td>
</tr>
<tr>
<td>TOTSOC</td>
<td>0.24 (1.60)</td>
<td>0.19 (1.53)</td>
</tr>
<tr>
<td>AGE*</td>
<td>-0.05 (-0.18)</td>
<td>0.17 (0.62)</td>
</tr>
<tr>
<td>EJFX</td>
<td>1.12 (0.43)</td>
<td>1.88 (0.86)</td>
</tr>
<tr>
<td>ED</td>
<td>1.80 (1.43)</td>
<td>2.27 (1.93)</td>
</tr>
</tbody>
</table>

*Change from negative to positive coefficient

Comparing Equation 1 with Equation 3 (Table 21) following the removal of outliers, the coefficient for age changed from a negative (-0.05) to a positive value (0.17) corresponding to expectations. Personality hardiness remains the most influential variable according to the standardized estimate (-0.40) which did not change between the two equations. Serum albumin was slightly less influential in the second model than the first. The model still did not achieve significance at the alpha = .05 level (p = 0.0880), and there were only minor changes in most of the parameter estimates, in the R-square, and the adjusted R-
square values. Although the two cases were influential, their deletion suggested that the model is probably under specified and that other medical, psychological or social variables need to be explored and added.

One Population Full Model Without Outliers "Best" Subset Selection

Using Akaike's AIC, Mallows' Cp, and Allen's PRESS, the following subsets (Table 22) were selected as the best models from the full model without the two outliers.

<table>
<thead>
<tr>
<th>Model</th>
<th>R2</th>
<th>ADJ R2</th>
<th>p</th>
<th>AIC</th>
<th>CP</th>
<th>PRESS</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2367</td>
<td>0.1674</td>
<td>0.0163</td>
<td>211.5435</td>
<td>3.0965</td>
<td>3849.5603</td>
<td>PH</td>
<td>ALB</td>
<td>ED</td>
<td>TOTSOC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.1980</td>
<td>0.1446</td>
<td>0.0182</td>
<td>211.9669</td>
<td>3.2307</td>
<td>3957.4792</td>
<td>PH</td>
<td>ALB</td>
<td>ED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.1505</td>
<td>0.1136</td>
<td>0.0235</td>
<td>212.7886</td>
<td>3.8525</td>
<td>3776.5656</td>
<td>PH</td>
<td>ALB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.2487</td>
<td>0.1613</td>
<td>0.0263</td>
<td>212.7726</td>
<td>4.4393</td>
<td>4004.1271</td>
<td>PH</td>
<td>ALB</td>
<td>ED</td>
<td>TOTSOC PIDBW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.2469</td>
<td>0.2469</td>
<td>0.0274</td>
<td>212.8861</td>
<td>4.5354</td>
<td>3995.9711</td>
<td>PH</td>
<td>ALB</td>
<td>ED</td>
<td>TOTSOC EJFX</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The lowest Allen's PRESS number (3776.5656) selects HLOS subset model #3 (equation 4) as the best model. The HLOS subset without outliers is statistically significant (p = 0.0235) and predicts approximately 15 percent ($R^2 = 0.1505$) of the variance in HLOS.

The one population without outliers, best subset HLOS model (selected by PRESS) is statistically significant (p = 0.0235) and
One Population W/O Outliers Best Subset HLOS Model 
(n = 50) (4)

HLOS = 41.15 - 7.57 ALB - 0.08 PERSHARD
(p value) (0.04) (0.07)

Std. Est. HLOS = - 0.28 ALB - 0.25 PERSHARD

R-Square = 0.1505
Adj. R-Square = 0.1136
p = 0.0235

predicts approximately 15 percent of the variance in HLOS. Albumin is the strongest variable in the equation (std. est. - 0.28) and is negatively associated with HLOS as expected. The PERSHARD variable is also negatively related as expected.

Two Population Model for HLOS

Consistently, the cardiovascular literature has reported a difference in outcomes of open heart surgery between men and women (Kennedy et al., 1980; Fisher et al., 1982; Loop et al., 1983). Based on this information, the data set was divided on the sex variable.

Men's Full Model of HLOS Following Open Heart Surgery 
(n = 38) (5)

HLOS = 6.03 - 4.79 ALB + 18.17 PIDBW -.216 PERSHARD +.213 TOTSOC + .16 AGE + 2.18 EJFX + 1.80 ED

(p value) (0.34) ALB (0.17) PIDBW (0.02) PERSHARD (0.17) TOTSOC (0.61) AGE (0.42) EJFX (0.05) ED

Std Est. HLOS = - 0.16 ALB + 0.248 PIDBW - 0.59 PERSHARD + 0.22 TOTSOC + 0.09 AGE + 0.13 EJFX + 0.41 ED

R-square = 0.3269
Adjusted R-square = 0.1644
P = 0.0878
The men’s full model of HLOS (equation 5) was not statistically significant \((p = 0.0878)\). The personality hardiness (PERHARD) variable with a standardized estimate of \(-0.59\) is the strongest variable in the equation and is negatively related to HLOS as expected. Albumin also maintains a negative association with HLOS. Mallows' Cp, Akaike's AIC, and Allen's PRESS were used to select the best subset models from the full model of men's HLOS following open heart surgery (Table 23).

**Table 23**

<table>
<thead>
<tr>
<th>Model</th>
<th>R²</th>
<th>ADJR²</th>
<th>(p =)</th>
<th>AIC</th>
<th>CP</th>
<th>PRESS</th>
<th>PH</th>
<th>PIDBIED</th>
<th>ED</th>
<th>ALB</th>
<th>TOTSOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2307</td>
<td>0.161</td>
<td>0.0323</td>
<td>169.5456</td>
<td>4.1423</td>
<td>4113.1125</td>
<td>PH</td>
<td>PIDBIED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.2228</td>
<td>0.150</td>
<td>0.0378</td>
<td>169.9266</td>
<td>4.4054</td>
<td>3914.5380</td>
<td>PH</td>
<td>ED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.2817</td>
<td>0.192</td>
<td>0.0277</td>
<td>169.0091</td>
<td>3.9465</td>
<td>3912.7052</td>
<td>PH</td>
<td>PIDBIED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.2681</td>
<td>0.177</td>
<td>0.0359</td>
<td>169.7033</td>
<td>4.5325</td>
<td>3806.0831</td>
<td>PH</td>
<td>ED</td>
<td>ALB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.3084</td>
<td>0.197</td>
<td>0.0354</td>
<td>169.6069</td>
<td>4.7956</td>
<td>3938.1974</td>
<td>PH</td>
<td>PIDBIED</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on the R-Square, the adjusted R-Square, and the \(p\) value alone, the best subset models in predicting men’s hospital length of stay are subsets 2 (Variables: PH, ED, ALB) and 3 (Variables: PH, PIDBIW, ED, TOTSOC). Using minimum values of Akaike’s AIC, however, subset number 3 (Variables: PIDBIW, ED, TOTSOC) is chosen. Allen's PRESS, the strongest of the selection criteria, selected subset 4 (ED, ALB, TOTSOC) which is presented in equation 6. The influence of albumin (subsets 2 and 4) on hospital length of stay is supported in the medical literature. Education as an indicator of socioeconomic status has also been linked to surgical outcomes, but is negatively associated with longer hospital stays in most studies (Sorel et al., 1992). The other variables of total social support and personality hardiness have not been reported as predictors in outcomes of open heart surgery.
Therefore, selection of the best subset model is chosen statistically and supported theoretically by the inclusion of the variables albumin and education.

**Men's "Best" Subset HLOS Model (n = 38)**  
(6)

\[
\text{HLOS} = 31.84 - 6.98\text{ALB} - 0.19\text{PH} + 0.21\text{TOTSOC} + 2.30\text{ED}
\]

(p value) (0.14)ALB (0.02)PH (0.17)TOTSOC (0.12)ED

Std. Est. HLOS

\[
\text{R-Square} = 0.2681
\]

\[
\text{Adj. R-Square} = 0.1766
\]

\[
p = 0.0359
\]

The men's best subset HLOS model selected by PRESS (Variables: ALB, PH, TOTSOC, and ED) is statistically significant (p = 0.0359) and predicts approximately 26.8 percent of the variance in the outcome variable. The personality hardiness variable, as indicated by the standardized estimate (-0.50), is the strongest variable.

The full model was used next to explain the outcome variable of acute HLOS in the women (Equation 7).

**Women's Full HLOS Model (n = 14)**  
(7)

\[
\text{HLOS} = 178.65 - 22.63\text{ALB} + 10.37\text{PIDBW} - 0.22\text{PERSHARD} + 0.61\text{TOTSOC} - 1.27\text{AGE} - 2.33\text{EJFX} + 0.40\text{ED}
\]

(p value) (0.36)ALB (0.89)PIDBW (0.54)PERSHARD (0.55)TOTSOC (0.58)AGE (0.86)EJFX (0.91)ED

STD Est. HLOS

\[
\text{R-square} = 0.4637
\]

\[
\text{Adjusted R-square} = -0.1619
\]

\[
p = 0.6508
\]
The women's full HLOS model did not achieve statistical significance \( (p = 0.6508) \) with the R-Square predicting approximately 46.3 percent of the HLOS. Albumin \( (\text{std. est.} = -0.70) \) is the strongest variable and negatively associated with the outcome variable. The best subset models based minimum Akaike’s AIC values, Mallows’ CP, and Allen’s PRESS were evaluated and are listed in Table 24.

### Table 24

#### Women’s “Best” Subset HLOS Models

<table>
<thead>
<tr>
<th>Model</th>
<th>R²</th>
<th>ADJ R²</th>
<th>( p = )</th>
<th>AIC</th>
<th>CP</th>
<th>PRESS</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1667</td>
<td>0.097</td>
<td>0.1472</td>
<td>070.9502</td>
<td>-0.6772</td>
<td>3032.5614</td>
<td>ALB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.3231</td>
<td>0.200</td>
<td>0.1169</td>
<td>070.0397</td>
<td>-0.4271</td>
<td>3037.8542</td>
<td>ALB</td>
<td>AGE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.3930</td>
<td>0.211</td>
<td>0.1563</td>
<td>070.5145</td>
<td>0.7912</td>
<td>3661.9498</td>
<td>ALB</td>
<td>AGE</td>
<td>PH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.3730</td>
<td>0.120</td>
<td>0.1793</td>
<td>070.9471</td>
<td>1.0044</td>
<td>4838.2908</td>
<td>ALB</td>
<td>TOTSOC</td>
<td>PIDBW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.4555</td>
<td>0.214</td>
<td>0.1978</td>
<td>070.9931</td>
<td>2.0919</td>
<td>3854.4707</td>
<td>ALB</td>
<td>AGE</td>
<td>PH</td>
<td>TOTSOC</td>
<td></td>
</tr>
</tbody>
</table>

The women’s best subset HLOS model selected by Allen’s PRESS from the above subsets is listed as equation 8.

#### Women’s “Best” Subset HLOS Model \( (n = 14) \) \( (8) \)

\[
\text{HLOS} = 59.64 - 13.22\text{ALB}
\]

\( p \text{ value} \quad (0.15)\text{ALB} \)

\( \text{Std. Est.} \quad 0 -0.40\text{ALB} \)

\( \text{R-Square} = 0.1667 \)

\( \text{Adj. R-Square} = 0.0973 \)

\( p = 0.1472 \)

The women’s best subset HLOS model does not achieve statistical significance and predicted 16.6 percent (adjusted R-square = 0.0973) of
the variance in women's HLOS. Albumin is the single predicting variable.

Using Akaike's AIC minimum values, the best HLOS subset for the one-population model and the sum of the men's best subset and women's best subset (two population model) were compared to determine which best represented the data set.

Table 25

<table>
<thead>
<tr>
<th>One Population &quot;Best&quot; HLOS Subset Model versus Men Plus Women's &quot;Best&quot; HLOS Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Population &quot;Best&quot; Subset</td>
</tr>
<tr>
<td>Men + Women's &quot;Best&quot; Subsets</td>
</tr>
<tr>
<td>Difference</td>
</tr>
</tbody>
</table>

The one population "best" HLOS subset model represents the data better or as well as the two population (men's plus women's) "best" subset models. The difference (less than two) between the minimum AIC values of the two models is considered ambiguous (Hammer, 1991).

After removing the outliers from the women's HLOS model, the subsets (Table 26) were evaluated again and equation 9 was selected.

Table 26

<table>
<thead>
<tr>
<th>Women's &quot;Best&quot; HLOS Subsets Without Outliers (n = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>
Women's "Best" HLOS Model Without Outliers (9)

\[ HLOS = 28.35 - 7.90ALB + 2.60EJFX + 2.90ED \]

\[ p \text{ value} = (0.04)ALB \quad (0.14)EJFX \quad (0.04)ED \]

\[ \text{Std. Est. } HLOS = -0.92ALB + 0.49EJFX + 1.03ED \]

R-Square = 0.4753
Adj. R-Square = 0.2786
p = 0.1417

The women's best HLOS subset without outliers is not statistically significant. The model predicts 47.5 percent (Adjusted R-square = 0.2786) of the variance in HLOS and education is the strongest variable (std. est. = 1.03). The very small sample size may account for the model's statistical weakness.

The one population HLOS best subset without outliers and the men's best subset plus women's best subset without outliers were then analyzed using Akaike's AIC minimum values to determine which best represented the data on acute HLOS (Table 27).

Table 27

<table>
<thead>
<tr>
<th>One Population &quot;Best&quot; HLOS Model Without Outliers versus Men Plus Women's &quot;Best&quot; HLOS Subsets Without Outliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Sample's HLOS &quot;Best&quot; Subset w/o Outliers = 212.7886</td>
</tr>
<tr>
<td>Men + Women's &quot;Best&quot; Subsets w/o Outliers</td>
</tr>
<tr>
<td>169.7033 + 23.1625</td>
</tr>
<tr>
<td>Difference</td>
</tr>
<tr>
<td>= 19.9228</td>
</tr>
</tbody>
</table>
The two population subset model (men’s best model and women’s best model without the outlier cases) represents the data better than the one population HLOS best subset model (without outlier cases). The difference between minimum AIC values of the one population best model without outliers and the sum of the men and women’s (without outliers) subsets is greater than two.

One Population Full Model of Intensive Care Hours (ICUHRS)

The second model (equation 10) examined the intensive care hours (ICUHRS) as an indicator of postoperative complications following open heart surgery. Correlation between ICUHRS and the acute HLOS was positive \( r = 0.2397, \text{NS} \) but not significant. However, patients with more hours of intensive care time have an increased use of hospital resources and a proportional increase in expense in health care dollars for the open heart surgery procedure.

One Population Full ICUHRS Model \((n = 52)\) \((10)\)

Men:

\[
\text{ICUHRS} = (-139.87 - 10.05) + 6.00\text{ALB} + 71.06\text{PIDBW} - 0.59\text{PERSHARD} + 0.62\text{TOTSOC} + 1.95\text{AGE} + 32.90\text{EJFX} + 2.49\text{ED}
\]

Women:

\[
\text{ICUHRS} = -139.87 + 6.00\text{ALB} + 71.06\text{PIDBW} - 0.59\text{PERSHARD} + 0.62\text{TOTSOC} + 1.95\text{AGE} + 32.90\text{EJFX} + 2.49\text{ED}
\]

p value. \((0.75)\text{ALB} \quad (0.10)\text{PIDBW} \quad (0.06)\text{PERSHARD} \quad (0.05)\text{TOTSOC} \quad (0.16)\text{AGE} \quad (0.006)\text{EJFX} \quad (0.66)\text{ED}

\[
\text{Std. Est. ICUHRS} = -0.04\text{ALB} + 0.23\text{PIDBW} - 1.67\text{PERSHARD} + 1.75\text{TOTSOC} + 0.21\text{AGE} + 0.39\text{EJFX} + 0.06\text{ED}
\]

R-Square = 0.3487

Adj. R-Square = 0.2276

\( p = 0.0117 \)
The model was statistically significant (p = 0.0117) with a coefficient of determination (R-square) of 0.3487. The strongest variable was social support (std. est. = 1.75) closely followed by personality hardiness (std. est. = -1.67). The personality hardiness variable is negatively associated with the outcome variable and supports the study hypothesis, but the social support variable is unexpectedly, positively related to ICUHRS.

The model was then analyzed (Table 28) to select the best subset models using Akaike's AIC.

Table 28

<table>
<thead>
<tr>
<th>Model</th>
<th>R²</th>
<th>ADJ R²</th>
<th>p =</th>
<th>AIC</th>
<th>CP</th>
<th>PRESS</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.3381</td>
<td>0.2662</td>
<td>0.0015</td>
<td>397.3149</td>
<td>3.7009</td>
<td>151065.4604</td>
<td>EJFX AGE PH PIDBW TOTSOC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.3089</td>
<td>0.2501</td>
<td>0.0014</td>
<td>397.5600</td>
<td>3.6295</td>
<td>202133.7818</td>
<td>EJFX PH PIDBW TOTSOC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.2734</td>
<td>0.2280</td>
<td>0.0014</td>
<td>398.1649</td>
<td>3.9735</td>
<td>139230.5809</td>
<td>EJFX AGE PIDBW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.2727</td>
<td>0.2273</td>
<td>0.0015</td>
<td>398.2140</td>
<td>4.0188</td>
<td>297695.8323</td>
<td>EJFX PH TOTSOC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Subset model #3 represents the data best according to the minimum PRESS value. The model is presented in equation 11.

One Population "Best" ICUHRS Subset (n = 52) (11)

MEN:
ICUHRS = (-194.03 -10.05) + 72.48PIDBW + 36.53EJFX + 2.9AGE

WOMEN:
ICUHRS = -194.03 + 72.48PIDBW + 36.53EJFX + 2.9AGE

p value (0.08)PIDBW (0.001)EJFX (0.02)AGE

Std. Est. ICUHRS = 0.23PIDBW + 0.43EJFX + 0.32AGE

R-Square = 0.2734
Adj. R-Square = 0.2280
p = 0.0014
This model (Variables: PIDBW, EJFX, and AGE) is highly significant \( p = 0.0014 \) and predicts 27.3 percent of the variability in ICUHRS. In the best subset for the full ICUHRS model, the ejection fraction is the strongest variable (std. est. 0.43). Age and ejection fraction are related to the outcome variable as expected.

Two Population ICUHRS Model

Based on cardiovascular medical literature which indicates different outcomes for men and women following open heart surgery, the data set was split on the sex variable (Kennedy et al., 1980; Fisher et al., 1982; Loop et al., 1983).

Men's Full ICUHRS Model \( (n = 38) \)

\[
\text{ICUHRS} = -208.70 - 4.34\text{ALB} - 13.25\text{PIDBW} - 0.26\text{PH} + 0.31\text{TOTSOC} + 3.41\text{AGE} + 39.29\text{EJFX} - 0.61\text{ED}
\]

\( p \) value. \( (0.84)\text{ALB} (0.81)\text{PIDBW} (0.49)\text{PH} (0.40)\text{TOTSOC} (0.02)\text{AGE} (0.002)\text{EJFX} (0.93)\text{ED} \)

STD Est. ICUHRS = -0.03\text{ALB} - .04\text{PIDBW} - 0.84\text{PH} + 1.00\text{TOTSOC} + 0.38\text{AGE} + 0.49\text{EJFX} - 0.02\text{ED} \)

\( \text{R-Square} = 0.4920 \)
\( \text{Adj. R-Square} = 0.3734 \)
\( p = 0.0027 \)

The men's full ICUHRS model (equation 12) explained 49 percent \( (\text{R-Square} = 0.4920) \) of the variability of the outcome variable and was statistically significant \( (p = 0.0027) \). The strongest variable is the social support variable (std est. = 1.00) with personality hardiness the next strongest (std est. = - 0.83). The men's sample was then analyzed...
for best subset models using Akaike's AIC, Allen's PRESS, and Mallows' Cp (Table 29).

Table 29

Men's "Best" Subset ICUHRS Models (n=38)

| Model | $R^2$ | ADJ $R^2$ | $p$= | AIC | CP | PRESS | VAR | VAR | VAR
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.4476</td>
<td>0.4176</td>
<td>0.0001</td>
<td>281.6782</td>
<td>0.6159</td>
<td>86270.1852</td>
<td>EJFX</td>
<td>AGE</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.4742</td>
<td>0.4279</td>
<td>0.0001</td>
<td>281.8045</td>
<td>1.0466</td>
<td>519424.5513</td>
<td>EJFX</td>
<td>AGE</td>
<td>TOTSOC</td>
</tr>
<tr>
<td>3</td>
<td>0.4685</td>
<td>0.4216</td>
<td>0.0001</td>
<td>282.2206</td>
<td>1.3885</td>
<td>120023.0865</td>
<td>EJFX</td>
<td>AGE</td>
<td>PH</td>
</tr>
</tbody>
</table>

The PRESS value selected model number one (equation 13) with two variables (EJFX and AGE).

Men's "Best" ICUHRS Subset Model

\[ \text{ICUHRS} = -290.95 + 40.92 \text{EJFX} + 4.28 \text{AGE} \]

$p$ value (0.0003) EJFX (0.0005) AGE

Std. Est. ICUHRS = 0.51 EJFX + 0.48 AGE

$R$-Square = 0.4477
Adj. $R$-Square = 0.4161
$p$ = 0.0001

The model (Variables: EJFX and AGE) is highly, statistically significant ($p = 0.0001$) and explains approximately 44.7 percent of the variability of ICUHRS in men.

The full model was then used to explain the dependent variable of ICUHRS in the women.
The women's full ICUHRS model did not achieve statistical significance. Subset model selection was used to determine if subsets would improve predictability in women's ICUHRS (Table 30).

Table 30

Women's "Best" ICUHRS Subset Models (n=14)

<table>
<thead>
<tr>
<th>Model</th>
<th>R2</th>
<th>ADJ R2</th>
<th>p</th>
<th>AIC</th>
<th>CP</th>
<th>PRESS</th>
<th>VAR</th>
<th>VAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.3969</td>
<td>0.3467</td>
<td>0.0157</td>
<td>104.6565</td>
<td>-2.7362</td>
<td>26532.2365</td>
<td>PIDBW</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.4747</td>
<td>0.3792</td>
<td>0.0290</td>
<td>104.7250</td>
<td>-1.6722</td>
<td>27057.0425</td>
<td>PIDBW, ALB</td>
<td></td>
</tr>
</tbody>
</table>

Women's "Best" ICUHRS Subset Model

ICUHRS = 53.07 + 151.56PIDBW

p value (0.12)PIDBW

Std. Est. ICUHRS = 0.63 PIDBW

R-Square = 0.3970

Adj. R-Square = 0.3467

p = 0.0157
The women's best ICUHRS subset model is statistically significant (p= 0.0157) and explains approximately 39.7 percent of the variability of ICUHRS in women. Percent of ideal body weight was the only variable.

If the summed AIC values of the two population "best" subset models for men and women are greater than 2 different than the AIC value for the one population "best" subset model (men and women combined), then the men's and women's subset models provide a better representation of the data set (Table 31).

Table 31

<table>
<thead>
<tr>
<th>One Population &quot;Best&quot; Subset ICUHRS Model Versus</th>
<th>Two Population &quot;Best&quot; ICUHRS Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Population &quot;Best&quot; Subset Model</td>
<td>398.1649 (AIC)</td>
</tr>
<tr>
<td>Two Population &quot;Best&quot; Subset Model (Men + Women)</td>
<td>281.67821 + 104.65653</td>
</tr>
<tr>
<td></td>
<td>386.3347 (AIC)</td>
</tr>
<tr>
<td></td>
<td>11.8302</td>
</tr>
</tbody>
</table>

The two population "best" ICUHRS subset models for men and women represent the ICUHRS data better than the one population "best" subset model. The difference between the one population "best" subset model and the two population "best" subset models for men and women is greater than two. Therefore the difference is not clear.
The women's sample had two outliers (identified first in the HLOS models), defined by Bollen and Jackman's criteria (1985) on the full ICUHRS model (Table 32). Characteristics of these two women were described under the HLOS model without outliers. A third potential outlier was also examined. This seventy-eight-year-old man did not present with any usual characteristics that would have substantively identified him as an influential case. His ICUHRS and HLOS were prolonged, and he eventually was discharged to a nursing home. He was not deleted from the final sample. The two women outliers were deleted from the total sample and the women's sample and the model on full ICUHRS model (equation 16) and the women's ICUHRS model (equation 17) were evaluated.

One Population Full ICUHRS Model W/O Outlier Cases (n = 50) (16)

Men:
ICUHRS=\(-216.90 - 12.09\) + 9.08ALB + 64.78PIDBW - 0.53PH + 0.56TOTSOC + 2.76AGE + 35.20EJFX + 5.58ED

Women:
ICUHRS=\(-216.90+9.08ALB+64.78PIDBW\) - 0.53PH + 0.56TOTSOC + 2.76AGE + 35.20EJFX + 5.58ED

p value 
(0.63)ALB (0.13)PIDBW (0.08)PH
(0.06)TOTSOC (0.05)AGE (0.002)EJFX (0.35)ED

Std. Est. ICUHRS = 0.06ALB + 0.21PIDBW - 1.57PH + 1.64TOTSOC + 0.31AGE + 0.43EJFX + 0.13ED

R-Square = 0.3902, Adj. R-Square = 0.2712, p = 0.0056
Following the removal of the two outlier cases, the coefficient of
determination (R-Square) increases from 0.3487 to 0.3902 and the p value
improves in the full model from \( p = 0.0117 \) to \( p = 0.0056 \). The
comparison of parameter coefficients are presented in Table 33. No
parameter signs change, and the social support variable (TOTSOC) remains
the strongest variable (Std. Est. = 1.64)

Table 33

Comparison of Intercept, Parameter Estimates (t ratios)
Between One Population Full Model and
One Population Full Model Without Outliers

<table>
<thead>
<tr>
<th>Intercept</th>
<th>Full Model* (n = 52)</th>
<th>Full Model W/O Outliers** (n = 50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALB</td>
<td>6.00 (0.32)</td>
<td>9.08 (0.48)</td>
</tr>
<tr>
<td>PIDBW</td>
<td>71.06 (1.67)</td>
<td>64.78 (1.55)</td>
</tr>
<tr>
<td>PERSHARD</td>
<td>-0.59 (-1.909)</td>
<td>-0.53 (-1.79)</td>
</tr>
<tr>
<td>TOTSOC</td>
<td>0.62 (2.02)</td>
<td>0.56 (1.90)</td>
</tr>
<tr>
<td>AGE</td>
<td>1.95 (1.42)</td>
<td>2.76 (2.05)</td>
</tr>
<tr>
<td>EJFX</td>
<td>32.90 (2.90)</td>
<td>35.20 (3.26)</td>
</tr>
<tr>
<td>ED</td>
<td>2.49 (0.45)</td>
<td>5.58 (0.95)</td>
</tr>
</tbody>
</table>

*R-Square = 0.3487, p = 0.0117
**R-Square = 0.3902, p = 0.0056

Women's Full ICUHRS Model W/O Outlier Cases (17)

ICUHRS = -263.58 - 46.15ALB + 83.35PIDBW + 0.04PH - 2.43TOTSOC + 5.29AGE + 48.39EJFX + 50.71ED

p value

\( (0.46)\)ALB \( (0.51)\)PIDBW \( (0.95)\)PH \( (0.16)\)TOTSOC
\( (0.21)\)AGE \( (0.10)\)EJFX \( (0.03)\)ED

Std. Est. ICUHRS = -0.34ALB + 0.39PIDBW + 0.03PH - 0.58TOTSOC + 0.62AGE + 0.58EJFX + 1.14ED

R-Square = 0.9135
Adj. R-Square = 0.7623
p = 0.0508
The removal of outlier cases from the women's full ICUHRS model greatly improved the R-Square of 0.5019 to a R-Square of 0.9135 and the F value achieved statistical significance (p = 0.0508).

Table 34 compares the parameter estimates (t ratios) in the independent variables in the women’s model and in the women’s model without the outliers. The parameter estimate changes are dramatic with signs changing in four independent variables (personality hardiness, social support, education, and age). The standardized estimate indicates that education (std. est. 1.14) has become the most important variable in the model.

Table 34

<table>
<thead>
<tr>
<th></th>
<th>Women’s Full Model* (n = 14)</th>
<th>Women’s Model W/O Outliers** (n = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-61.00 (-0.07)</td>
<td>-263.58 (-0.62)</td>
</tr>
<tr>
<td>ALB+</td>
<td>31.11 (0.36)</td>
<td>-46.14 (-0.83)</td>
</tr>
<tr>
<td>P1DBW</td>
<td>185.74 (0.70)</td>
<td>83.35 (0.72)</td>
</tr>
<tr>
<td>PERSHARD+</td>
<td>-0.16 (-0.124)</td>
<td>0.04 (0.07)</td>
</tr>
<tr>
<td>TOTSOC+</td>
<td>0.75 (0.245)</td>
<td>-2.43 (-1.70)</td>
</tr>
<tr>
<td>AGE+</td>
<td>-0.10 (-0.01)</td>
<td>5.28 (1.47)</td>
</tr>
<tr>
<td>EJFX</td>
<td>1.29 (0.03)</td>
<td>48.37 (2.17)</td>
</tr>
<tr>
<td>ED+</td>
<td>-3.11 (-0.247)</td>
<td>50.71 (3.39)</td>
</tr>
</tbody>
</table>

+ Sign change
*R-Square = 0.5019, p = 0.5793
**R-Square = 0.9135 , p = 0.0508

Using Mallows’ Cp, Akaike’s AIC, and Allen’s PRESS the best subset models were again selected for the full ICUHRS model without outliers and for the women’s best ICUHRS model without outliers.
Table 35

One Population "Best" Subset ICUHRS Model Without Outliers (n = 50)

<table>
<thead>
<tr>
<th>Model</th>
<th>R2</th>
<th>ADJ R2</th>
<th>p</th>
<th>AIC</th>
<th>CP</th>
<th>PRESS</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.3158</td>
<td>0.2711</td>
<td>0.0005</td>
<td>377.6545</td>
<td>4.0055</td>
<td>125996.7786 EJFX AGE PIDBW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.3664</td>
<td>0.2944</td>
<td>0.0009</td>
<td>377.8124</td>
<td>4.6028</td>
<td>167312.6063 EJFX AGE PIDBW TOTSOC PH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.2801</td>
<td>0.2494</td>
<td>0.0004</td>
<td>378.1969</td>
<td>4.4053</td>
<td>116664.5726 EJFX AGE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.3336</td>
<td>0.2744</td>
<td>0.0009</td>
<td>378.3344</td>
<td>4.8067</td>
<td>239476.6750 EJFX AGE TOTSOC PH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.3294</td>
<td>0.2698</td>
<td>0.0010</td>
<td>378.6453</td>
<td>5.0863</td>
<td>138429.1051 EJFX AGE PIDBW TOTSOC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.3022</td>
<td>0.2567</td>
<td>0.0008</td>
<td>378.6389</td>
<td>4.9020</td>
<td>178146.5266 EJFX AGE TOTSOC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Allen's PRESS minimum value selects model 3 which uses two variables (EJFX and AGE). The model is statistically significant (p = 0.0004) and explains approximately 28 percent of the variability in intensive care hours (equation 18).

One Population Best ICUHRS Model W/O Outliers (n = 50) (18)

MEN:
ICUHRS = (-180.21 -10.05) + 35.28EJFX + 2.84AGE

WOMEN:
ICUHRS = -180.21 + 35.28EJFX + 2.84AGE

p value (0.001)EJFX (0.01)AGE

Std. Est. ICUHRS = 0.43EJFX + 0.32AGE

R-Square = 0.2801
Adj. R-Square = 0.2494
p = 0.0004

The one population best ICUHRS model without outliers is statistically significant (p = 0.0004) and explains approximately 28 percent of the variability in ICUHRS. Ejection fraction is the strongest variable (std. est. 0.43).
Table 36

Women's "Best" ICUHRS Subset Models W/O Outliers (n=12)

<table>
<thead>
<tr>
<th>Model</th>
<th>R²</th>
<th>ADJ R²</th>
<th>p</th>
<th>AIC</th>
<th>CP</th>
<th>PRESS</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
<th>VAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.8998</td>
<td>0.7981</td>
<td>0.0070</td>
<td>0.5277</td>
<td>5.0953</td>
<td>8115.6916</td>
<td>EJFX</td>
<td>AGE</td>
<td>TOTSOC</td>
<td>ALB</td>
<td>ED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.9135</td>
<td>0.7623</td>
<td>0.0508</td>
<td>0.6235</td>
<td>8.0000</td>
<td>13878.9890</td>
<td>EJFX</td>
<td>AGE</td>
<td>TOTSOC</td>
<td>ALB</td>
<td>EDPIDBW</td>
<td>PH</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Women's "Best" ICUHRS Subset Model W/O Outliers (n=12) (19)

ICUHRS = 95.88 – 62.31ALB – 3.40TOTSOC + 3.84AGE + 61.40EJFX + 54.07ED

p value (0.08)ALB (0.002)TOTSOC (0.06)AGE (0.005)EJFX
(0.005)ED

Std. Est. ICUHRS = - 0.46ALB - 0.86TOTSOC + 0.45AGE + 0.74EJFX + 1.23ED

R-Square = 0.89
Adj. R-Square = 0.80
p = 0.0077

The women's best ICUHRS subset model without outliers is highly, statistically significant (p = 0.0077) and explains approximately 89 percent of the variability in women's ICUHRS. Education (std. est. = 1.23) is the strongest variable in the model. Albumin and social support are negatively related to the outcome variable as expected.

The best subset of the one population ICUHRS model and the best subsets of the two population models for men and women were then analyzed using Akaike's AIC minimum values to determine whether the one population model subset or the two population models of the men's and women's subsets best represented the ICUHRS data.
Table 37

<table>
<thead>
<tr>
<th>One Population &quot;Best&quot; ICUHRS Subset Model W/O Outliers versus Two Population &quot;Best&quot; ICUHRS Subset Models W/O Outliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Population &quot;Best&quot; Subset Model = 378.1969 (AIC)</td>
</tr>
<tr>
<td>Two Population &quot;Best&quot; Subset Models (Men's + Women's)</td>
</tr>
<tr>
<td>281.6782 + 74.5277 = 356.2059 (AIC)</td>
</tr>
<tr>
<td>Difference = 21.9910</td>
</tr>
</tbody>
</table>

The two population "best" ICUHRS subset models for men and women without outliers represent the ICUHRS data better than the one population "best" subset model without outliers. The difference between the total sample "best" subset model and the combined "best" subset models for men and women is greater than two.

Summary of Statistical Results

Four statistical subset models (Table 38) best predicted the outcome variables of HLOS and ICUHRS in patients undergoing elective or non-emergent open heart surgery. The separate models for men and women predicted outcomes better than the one population models for both outcome variables. Subset models were selected using Akaike's AIC (a parametric test which tends to select several appropriate subset models within one minimum value), Allen's PRESS (a nonparametric test which tends to select the best subset model and is the strongest of the criteria), and Mallows' Cp which narrowed the field of possible subsets and diagnosed bias. When the Akaike's AIC and the Allen's PRESS are in agreement, it is reasonable to assume multivariate normality. The
subset models listed in Table 38 were selected by the Allen's PRESS values which agreed 100 percent with Akaike's AIC values within 1 in each of the models indicating multivariate normality. Mallows' Cp eliminated the one population models as biased supporting the selection of the two population models for both outcome variables (Figure 3 and 4).

Plotting each of the six best models (three for HLOS and three for ICUHRS) using the number of regression parameters plus one for the intercept (x axis) by the Mallows' Cp score (y axis) examines each of the models for bias. Models whose Mallows' Cp lies above the diagonal line are more likely to be biased or misrepresent the data than those models who Cp scores are below the line. Figure 3 examines the three models for hospital length of stay: (1) the one population model which represents the total sample of subjects without outliers and the two population models which represent the (2) men in the sample and the (3) women in the sample separately.

The one population HLOS model statistic lies above the Cp = p+1 line indicating a biased model. The two population models for men and women lie below the line and probably predict hospital length of stay more accurately. This statistical outcome agrees with other statistical procedures, i.e., the selection of the two population model using the AIC minimum scores, and the medical literature which reports different outcomes for men and women undergoing open heart surgery.

The one population ICUHRS subset model also lies above the Cp = p+1 line indicating that this model is biased. The two population models for men and women lie below the line are are more likely to
Figure 3: Hospital Length of Stay Models by Mallows' Cp

Figure 4: Intensive Care Hour Models by Mallows' Cp
predict intensive care hours (post operative complications) more accurately. This statistical outcome agrees with the AIC selection criteria for the two population model and the medical literature which reports increased complications requiring intensive care in women undergoing open heart surgery.

Table 38

Summary of "Best" Statistical Models in Predicting HLOS and ICUHRS

I. HLOS:

MEN'S HLOS = 31.84 - 6.98ALB - 0.19PERSHARD + 0.21TOTSOC + 2.30ED
(Std. Est. HLOS = - 0.23ALB - 0.50PERSHARD + 0.22TOTSOC + 0.29ED)
(R-square = 0.2681; Adjusted R-square = 0.1766; p = 0.0359)

WOMEN'S HLOS* = 28.35 - 7.90ALB + 2.60EJFX + 2.90ED
(Std. Est. HLOS = - 0.92ALB + 0.49EJFX + 1.03ED)
(R-square = 0.4753; Adjusted R-square = 0.2786; p = 0.1417)
*Without 2 outliers

II. ICUHRS:

MEN'S ICUHRS = -290.95 + 40.92EJFX + 4.28AGE
(Std. Est. ICUHRS=0.51 EJFX + 0.48AGE)
(R-square = 0.44771; Adjusted R-square = 0.4161; p = 0.0001)

WOMEN'S ICUHRS* = 95.88- 62.31ALB - 3.40TOTSOC+3.84AGE + 61.40EJFX + 54.07ED
(Std. Est. ICUHRS = - 0.46ALB - 0.86TOTSOC + 0.45AGE + 0.74EJFX + 1.23ED)
(R-Square = 0.89; Adjusted R-square = 0.80; p = 0.0077)
*Without 2 outliers

The personality hardiness variable was the strongest (std. est. 0.50) in the men's subset model on HLOS. Education (std. est. 1.03) is the strongest predicting variable in the women's model on HLOS which was not statistically significant.
In the ICUHRS models, ejection fraction is the predominant variable in the men's subset model (std. est. 0.51). Education (std. est. 1.23) is the strongest variable in the women's subset model. Age consistently appeared in both models. Only the women's subset incorporates the social support variable and the albumin variable in the ICUHRS model.

**Hypotheses**

Controlling for the intervening variables of severity of illness, age, sex, ethnicity, and socioeconomic status,

Older adults with a good nutritional status, positive personality hardiness, and positive social support prior to hospitalization will have fewer hours in the intensive care.

Older adults with a good nutritional status, positive personality hardiness, and positive social support prior to hospitalization will have a shorter acute hospital length of stay following planned surgical treatment.

Neither of the two study hypotheses were fully supported in this study. In the one population full HLOS model, which was not statistically significant, only personality hardiness and albumin were negatively related to the outcome variable. The social support variable was positively related. In the full HLOS models for men and women separately, which were also not statistically significant, personality
hardiness and albumin representing nutritional status were negatively
related to HLOS. Social support and percent of ideal body weight were
both positively related to HLOS.

The ICUHRS full model and ICUHRS full models based on sex were
statistically significant, but study variables performed differently
than expected. The personality hardiness was negatively related and
predicted number of complications (ICUHRS) in the one population full
model ($p = 0.0117$) as predicted. Without the two women outlier cases,
the personality hardiness remained the only variable which contributed
to ICUHRS as expected (negatively related to outcome) in the full ICUHRS
model ($p = 0.0056$). In the men's full ICUHRS model ($p = 0.0027$)
personality hardiness, albumin, and percent of ideal body weight were
negatively related and predictors of ICUHRS as postulated. However, the
social support variable was positively related to ICUHRS in men.

In women, the full model for ICUHRS was not statistically
significant and only the personality hardiness variable was negatively
related to the outcome variable. Without outliers, however, the full
model was statistically significant ($p = 0.0508$) and the albumin and
social support variables were negatively associated with the outcome
variable as postulated. The personality hardiness and percent of ideal
body weight variables were positively associated with the outcome
variable.

The primary independent variables (ALB, PIDBW, TOTSOC, PH) were
supported in some of the best statistical subset models predicting HLOS
and ICUHRS. Personality hardiness and albumin were negatively related
to HLOS in the one population best subset model and in the men's best
subset model as postulated. The total social support variable, however, did not appear in the total sample's model and was positively related to HLOS in the men's best subset model. Albumin was also negatively related to HLOS in the women's best HLOS model as postulated. Personality hardiness and social support did not appear in the subset model for women.

The primary independent variables were not represented in the final subset ICUHRS models for one population or for men. However, albumin and total social support were both negatively related to ICUHRS in the women's best subset model for this outcome variable.
CHAPTER 5
DISCUSSION

Predicting individual patient responses to surgical or medical treatment is complicated by the individuality of the person receiving the treatment, the individual responses to disease as well as the professionals and facilities offering the treatment. When statistical models are based on one aspect of the individual response, such as present or past medical conditions or nutritional status, the models are difficult to replicate when tested on different samples of patients. Statistical techniques used to formulate predictive models may also have inherent flaws that make replication difficult. For example, older methods of stepwise regression which only use statistically significant variables in the final models may omit important variables. Frequently, statistical models reflect the researcher's field of study only and fail to take other factors into consideration. By broadening these models to include other aspects of the individual which may impact outcome, the models may prove more beneficial in providing usable information in informed consent and in preparing patients for elective procedures. This study examined statistical models which included the medical condition prior to and at the time of treatment, the nutritional status, the psychological, and social support status of the patient in a homogeneous treatment environment. Additionally, newer methods of statistical subset model selection were incorporated.
Summary of Results

Fifty-two subjects, 60 years of age and older, completed this six-month study examining how well seven preoperative characteristics (nutritional status, personality hardiness, social support, sex, age, ejection fraction and education) explained two outcome variables (number of hours in intensive care and acute hospital length of stay) following elective or non-emergent open heart surgery. Japanese-American men and women composed 48 percent of the total sample. There were six Caucasian subjects. The remaining 21 subjects were divided among eight other ethnic categories. Men (n = 38) outnumbered women (n = 14) almost three to one which is consistent with the cardiovascular literature (Rose, Gelbfish, Jacobowitz, Kramer, Zisbrod et al., 1985). The sample means for men and women were not significantly different in age, level of education which was used as an indicator of socioeconomic status, severity of heart disease as measured by left ventricular ejection fraction, nutritional status, personality hardiness, or levels of social support. Men and women differed on the types of secondary diagnoses indicated in the medical record with men having a stronger history of smoking and more prior heart surgery. Women had a stronger history of diabetes. Hypertension was prevalent (78.8%) in both sexes with equal histories of myocardial infarction and cerebral vascular accidents. The two sexes were not statistically different in the number of secondary diagnoses listed. Men and women were not significantly different in their respective hospital length of stay. However, women’s average hours spent in the intensive care was statistically different (p < 0.005) from the men’s. Death rates in the two groups were not
statistically different during hospitalization nor 90 days after surgery. Women had a mortality rate of 14.3 percent during hospitalization and both deaths occurred during hospitalization for surgery. Men had a 2.6 percent death rate during the initial hospitalization, but had a 10.5 percent by the end of 90 days. The death rate for the initial hospitalization for this sample was 5.7 percent and 11.5 percent at 90 days after surgery. Death rates in this sample for initial hospitalization is comparable with reports in the cardiovascular literature (Rose et al., 1985).

The primary independent variables were selected from the medical, nursing and psychological literature and from the personal experience of the researcher following seven years of study. Two variables, serum albumin and percent of ideal body weight, represented the nutritional status of older adults. The negative relationship of serum albumin to men's and women's age in this study agrees with reported medical-nutritional literature (Munro, McGandy, Hartz, Russell, Jacob, & Otradovec, 1987). A strong negative correlation between serum albumin and the two outcome variables (HLOS and ICUHRS) was also found. The serum albumin, which has been reported in 15 years of medical-nutritional literature as a consistent predictor of surgical outcome, served as an important predictor variable in the one population (men and women combined) best subset model as well as the separate men's and women's best subset models of HLOS. The serum albumin was a predictor variable in women's ICUHRS, which agrees with work completed by Rich and colleagues (1989).
The percent of ideal body weight (if greater than or less than 90 percent of the recommended standard) has been reported to detect patients at risk of increased morbidity and mortality. Twenty-six (50%) of the study sample were more than 10 percent over the ideal body weight, four (7.6%) were below their ideal body weight, and 22 (42%) were within 90 percent of their ideal body weight. Three of the six patients who died were 10 percent or more over their ideal body weight. The remaining three who died were within 90 percent of their ideal body weight. This variable did not appear in any of the final "best" predictor models. Percent of ideal body weight was weakly related to other study variables in the men's sample. The percent of ideal body weight variable assisted in identifying one women outlier case who had a major complication and a long hospital stay. In women, the PIDBW variable was negatively, significantly related to social support and moderately related to personality hardiness. This association may be interesting in future studies of ideal body weight in women.

Personality hardiness, developed by Kobasa (1979) was developed in studies of men and the variable proved strongest in the men's statistical models. The personality hardiness variable was the strongest variable in the one population (both men and women) HLOS model and the best subset of the men's HLOS model. The personality hardiness variable was moderately strong in the women's HLOS model but was surpassed by albumin. The personality hardiness variable did not persevere into the best subsets for the women's HLOS model. In women, personality hardiness is moderately related to social support, percent of ideal body weight, and number of hours spent in the intensive care
unit. The poor performance of this variable in women's models may indicate a need to determine better indicators of personality hardiness in this group. The variable may be stronger in younger, more educated women.

Social support (Tilden, 1989) was more strongly related to the independent and dependent variables in women. The most striking negative relationship was between social support and percent of ideal body weight. Even removing one influential case, an obese women who suffered an myocardial infarction during hospitalization, did not change this relationship. In the women's ICUHRS best subset model, the social support variable was the strongest variable and negatively associated with the outcome variable. The social support variable was weakly correlated with independent and dependent variables in men except for personality hardiness. This may indicate that the questionnaire is more sensitive to measuring social support as perceived by women. Additionally, the social support variable in men was associated positively with the outcome variable. This positive association with longer ICU stays may indicate a non-therapeutic social support system especially in men. Kobasa and Pucetti (1983) also found mixed results in relationships of personality hardiness to social support. Social support from family was found related to increased illness in executive men. On the other hand, social support from bosses or peers was related to decreased illnesses. Interestingly, the social support variable was positively related to HLOS in men in this study's best subset model. This may indicate that tools may need to be sensitive to more than just
family and friends as an immediate source of social support especially in men.

The sex variable, which was not significant in the full model, proved strongest in dividing the models into subsets. Men and women respond differently to cardiovascular surgery which is recognized in the literature (Gersh et al., 1981; Faro et al., 1983). However, women in this sample were not significantly older, sicker, but did die quicker as is frequently reported in the medical literature. Women are definitely in the minority as candidates for open heart surgery even though heart disease is the leading cause of death in this age group. Variables that predict outcomes in women are different than those predicting outcomes in men. For this reason, the existing models in the literature which are dominated by data on men may be inappropriate for predicting outcomes women. Clearly, more research identifying characteristics of women with heart disease as related to outcomes is needed.

Age was not found to contribute significantly to the best subset HLOS models for the total sample (one population), the men or women. However, age was present in all three of the ICUHRS best models. Age was moderately, negatively related to ICUHRS in women and moderately, positively related to ICUHRS in men. This reverse relationship of age to ICUHRS between the sexes needs further exploration. The small women's sample may have contributed to the dichotomy. Age was moderately, negatively related to percent of ideal body weight in women and very weakly related to percent of ideal body weight in men.

Severity of illness, as measured by the left ventricular ejection fraction (EJFX) figured prominently in predicting ICUHRS. The ejection
fraction was significantly correlated with ICUHRS in the total sample and in men and was the strongest variable in these two models. The ejection fraction was not significantly correlated to ICUHRS in women with and without outlier cases, but the variable was included in the best subset model by statistical selection criteria. This may indicate that ejection fraction needs further exploration as a predictor variable in women. The ejection fraction was also significantly correlated to education in the total sample, but not in the models specific to men and women separately. Although interesting, this relationship is unclear and poses questions of whether people with more education (higher socioeconomic status) have more severe forms of heart disease or do people with more education seek more surgical treatment or later surgical treatment than people with less education. Other than ICUHRS which represented postoperative complications and education which represented socioeconomic status, ejection fraction did not demonstrate strong relationships to other variables in this sample.

Education as a measure of socioeconomic status, except for its relationship with ICUHRS, was not significantly correlated with other study variables. Unlike Epstein and colleagues (1990), this study did not find lower education, thus lower socioeconomic status, related to more postoperative complications nor longer hospital stays. This may indicate that this small sample was very homogeneous, which is supported by the variable distribution, mean and standard deviation. Education was mildly related to personality hardiness (PH) in men, but very poorly related to personality hardiness in women.
This study confirms the findings that outcomes for open heart surgery, i.e., complications, are different in men and women. The death rate, however, was not statistically different. The statistical models that have been developed for the total sample of this study and former studies primarily reflect variables that measure characteristics in men. The small number of women in this sample clouds the issue. It was very difficult to find women who met the study criteria. This may indicate that women do not seek therapy nor undergo cardiovascular surgery as soon after symptoms occur as men. Death rates for both groups may be higher than generally reported if examined at 30, 60 and 90 days postoperatively.

Neither of the two study hypotheses were supported in this study. None of the full models (one population, men’s or women’s) on HLOS achieved statistical significance. Personality hardiness and nutritional status, as represented by the albumin variable, were negatively related to HLOS in the one population full model and in the men’s and women’s models. The social support and percent of ideal body weight variables were the reverse of the hypothesis and positively related to HLOS.

The ICUHRS models were the stronger models with the one population full model ($p = 0.0117$), the one population full model without outlier cases ($p = 0.0056$), and men’s model ($p = 0.0027$) reaching statistical significance. Only the personality hardiness variable was negatively associated with ICUHRS as expected in the one population full model and the one population full model without outlier cases. The study variables (personality hardiness, albumin, and percent of ideal body
weight) were all negatively associated with the outcome variable in the men's model. However, the social support variable, as stated earlier, was positively associated with number of ICUHRS in this group. The women's full model without outliers was statistically significant (p = 0.0508), but only albumin and social support were negatively associated with the outcome variable.

Of the best, most parsimonious, models developed by multivariate analysis and subset selection criteria, the model predicting ICUHRS (p = 0.0056) was statistically stronger than the HLOS model (p = 0.0235). New personality (personality hardiness) and sociological (social support) variables, which have not been identified previously as contributors to HLOS or ICUHRS, need further testing and may provide guidelines for allocation of resources, family intervention, preoperative educational programs, and during informed consent for surgical procedures.

The results of personality hardiness and social support in this population of patients have not been reported prior to this study. The tools appeared biased—personality hardiness to men and social support to women—in this sample and need more exploration with mixed groups. The high correlation of personality hardiness and the social support variable in men may have caused problems with the model development for men. The variables identified that are specific to gender may, however, assist with planning treatment for individual patients over the age of 60 years and should be tested in continued research. Personality hardiness may be able to be improved through education in men and women. Serum albumin, if not reduced secondary to infection or fluid balance
abnormalities, should be improved through dietary interventions in both men and women prior to elective surgical intervention. There is no clear indication that weight change would have made any difference in outcomes in this sample.

Limitations

This study is specific to men and women, 60 years of age and older, undergoing open heart surgery in Honolulu, Hawaii. Results should not be generalized to other age levels. In addition, the results of this hospital-based sample cannot be generalized to other hospital populations with different cultural components, the Honolulu community, or the general population.

Inasmuch as an older person's responses to psychological and social surveys have been found to be inconsistent in repeated testing, the results from this study would be more reliable if older individuals could be tested on several different days. Biochemical laboratory tests may be influenced by the underlying pathology (such as fluid imbalances, renal disease, or undetected infection) and may not represent the nutritional status of every patient. The social support in this age group may be limited and especially limited if the patient has had several illness episodes prior to this admission. Measurement of personality hardiness has not been reported in older adults and is not as sensitive in women in this sample. However, some studies have indicated that the issue of internal control (a component of personality hardiness) changes or relaxes after a person retires from work due to the lowered demands of day-to-day living (Knoop, 1989). Studies of
changes of locus of control after prolonged illness, especially in the elderly, are not reported.

**Meaning and Public Health Relevance**

There is very little evidence that this sample of patients was in compromised nutritional status prior to admission. This may indicate that the group came from a homogeneous socioeconomic group which is more likely to be well nourished. Therefore, this study would not support a wide-spread screening for malnutrition in older adults seeking elective open heart surgery. There is support, however, for monitoring protein status (serum albumin) of older patients undergoing elective treatment procedures.

This age group responded very well to surgical treatment. Morbidity and mortality are comparable to other study centers. However, more examination of outcomes (morbidity and mortality) at 30, 60 and 90 days is needed before more resources are devoted only to this type of treatment in this age group.

**Implications for Research**

The following is a list of proposed research topics that evolved during the analysis of the present study. They are listed in the priority of interest of the principal investigator.

1. Test models developed in this study in future prospective study of men and women undergoing non-emergent cardiac surgery.

2. Study of heart disease in women is needed to identify variables specific to women.
3. Explore concept of personality hardiness in women, especially in professionally educated women, and develop more specific indicators for women.

4. Explore concept of social support in men and develop more specific indicators for men and women as separate groups. Explore types of social support in relationship to therapeutic versus non-therapeutic results in the clinical setting.

5. Explore concept of social support in relationship to illness and age in both men and women.

6. Explore the relationship of education to personality hardiness and age.

7. Develop a long term (5-year), prospective study of healthy older adults using sexually specific tools (personality hardiness, social support, and nutritional status) and documenting medical events and mortality.
APPENDIX A
DEMOGRAPHIC DATA

Research ID #______________________

NUTRITIONAL STATUS, PERSONALITY HARDINESS, AND SOCIAL SUPPORT OF THE ELDERLY RELATED TO HOSPITAL LENGTH OF STAY FOLLOWING NON-EMERGENT SURGERY

General Information

Name________________________________________

Address_____________________________________

____________________________________________ Zip Code ___

Home Phone________________________

Number of Living Children______________

1. Do you live alone? ________ Yes ________ No

2. If no, who lives with you? __________________________________________ (name)

3. Relationship of person who lives with you______________________________ (son, daughter, spouse, friend)

4. What is your present or former occupation? ____________________________

5. If retired, did you retire in the past 12 months? __Yes____ No

6. What plans (appointments, jobs, vacations, family functions) to do you have for after surgery?

7. Currently, are you able to shop for your own food and supplies? Yes ___ No____

8. Do you have someone who will stay with you following hospitalization? __Yes ____ No

If yes, who________________________ (relationship)________? 

9. Do you have any physical limitations at this time? ____Yes___No.
   (poor vision, hearing loss, confined to wheelchair, unable to climb stairs)
## APPENDIX B
### NUTRITIONAL STATUS TOOL

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<thead>
<tr>
<th>Name</th>
<th>Code</th>
<th>RESULTS</th>
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<td>Scheduled Date of Admission</td>
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<td>Admitting Diagnosis</td>
<td>RX</td>
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<td>ICD 9 Code</td>
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<tr>
<td>Surgeon</td>
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<td></td>
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<tr>
<td>Cardiologist</td>
<td>CARD.</td>
<td></td>
</tr>
</tbody>
</table>

### ANTHROPOMETRICS
1. HEIGHT in cm (Standing X 2: agree within 1.0 cm) without shoes | NT |
2. KNEE HEIGHT (Sitting X 2, right leg, agree within 0.5cm) | KHT |
3. Stature from KNEE HEIGHT (derived) | SKHT |
4. WEIGHT in lbs (divide by 2.2 = wt. in kg.) street clothes without shoes | WX |
5. USUAL BODY WEIGHT | UBW |
6. IDEAL BODY WEIGHT (IBW) | IBW |
7. WEIGHT as percent of the Ideal Body Weight (IBW) | %IBW |
8. WEIGHT as percent of Usual Body Weight (derived) | %UBW |
9. TRICEPS SKINFOLD in mm | TSF |
10. TRICEPS SKINFOLD as percent of standard (derived) | %TSF |
11. MIDARM CIRCUMFERENCE in cm | MAC |
12. MIDARM MUSCLE CIRCUMFERENCE as percent of standard (derived) | %MAC |
13. WEIGHT/STATURE SQUARED (derived) | WSS |
14. GRIP STRENGTH (Kg) | GS |

### BIOCHEMICAL STUDIES and BLOOD STUDIES
15. SMAC 20 | SMAC |
A. SERUM ALBUMIN | ALB |
B. CHOLESTEROL | CHOL |
C. BLOOD SUGAR | BS |
D. BLOOD UREA NITROGEN | BUN |
E. CREATININE | CR |
F. BLOOD UREA NITROGEN/CREATININE | BUNCR |
G. TRIGLYCERIDES | TRG |
16. COMPLETE BLOOD COUNT | CBC |
A. HEMOGLOBIN | HGB |
B. HEMATOCRIT | HCT |
C. WHITE BLOOD CELL COUNT | WBC |
D. TOTAL LYMPHOCYTES (DERIVED) | LIMP |
17. SERUM TRANSFERRIN | TRANS |

### DIET & NUTRITION
18. HISTORY OF SPECIAL DIET (VEGETARIAN, FOOD ALLERGIES, DIABETES?) | FOOD |
LIST FOODS AVOIDED OR OBVIOUS DEFICIENCIES | |

### PROTEIN INTAKE
SUPPLEMENTS (Rx OR OTC) | |

### RECENT WEIGHT CHANGE: LOSS OR GAIN (DURING PAST SIX MONTHS) | WTCHG |
PT. EXPLANATION | |
PLANNED | |
UNPLANNED | |

### BASAL ENERGY EXPENDITURE IN KCAL/DAY (derived) | REE |
INDIRECT CALORIMETRY IN KCAL (attach report to data sheet) | IC |
RESPIRATORY QUOTIENT (derived) | RQ |

**Bold type indicates mandatory intake information at time of PREOP INTERVIEW.**

*Lab tests not routinely done by physician will be paid by study
Use special lab requisitions (all transferrins are paid by study)

Tool Developed from Blackburn et al., 1977; Kidjian et al., 1980; Karkeck, 1984; and Barrocas, 1986
PERSONALITY HARDINESS TOOL

PERSONALITY HARDINESS SURVEY

This survey gives clues on how you as a person deal with stress. There are no right or wrong answers. Your opinions are just as important as any others.

Below are statements with which you probably agree or disagree. Please indicate how you feel about each one by putting a circle around one number from -3 (STRONGLY DISAGREE) to +3 (STRONGLY AGREE) for each statement.

Please do not leave any items blank. If you need help, we will be glad to assist you.
1. I wake up eager to take up my life where it left off the day before. 
   
2. Politicians run our lives. 
   
3. Planning ahead can help avoid future problems. 
   
4. I feel that I can change what might happen tomorrow, by what I do today. 
   
5. I feel uncomfortable if I have to make changes in my everyday schedule. 
   
6. No matter how hard I try, my efforts will accomplish nothing. 
   
7. I find it difficult to imagine getting excited about working for a living. 
   
8. No matter what you do, the "tried and true" ways are best. 
   
9. People who work for a living are just manipulated by their bosses. 
   
10. When you get involved in a relationship you lose your freedom of choice. 
   
11. No matter how hard you work, you never seem to reach your goals. 
   
12. I believe what happens in life is just meant to happen. 
   
13. It doesn't matter if you work hard at your job, since only the bosses profit by it anyway. 
   
14. I don't like conversations when others are confused about what they mean to say.
<p>| | | | | | | | | |</p>
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</tr>
</thead>
<tbody>
<tr>
<td>15.</td>
<td>The most exciting thing for me is my own fantasies.</td>
<td>Disagree Strongly</td>
<td>Disagree</td>
<td>Disagree Slightly</td>
<td>Agree Slightly</td>
<td>Agree</td>
<td>Agree Strongly</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-3</td>
<td>-2</td>
<td>-1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>When I make plans I'm certain I can make them work.</td>
<td>Disagree Strongly</td>
<td>Disagree</td>
<td>Disagree Slightly</td>
<td>Agree Slightly</td>
<td>Agree</td>
<td>Agree Strongly</td>
<td></td>
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<tr>
<td></td>
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<td>1</td>
<td>2</td>
<td>3</td>
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</tr>
<tr>
<td>17.</td>
<td>It's exciting for me to learn something about myself.</td>
<td>Disagree Strongly</td>
<td>Disagree</td>
<td>Disagree Slightly</td>
<td>Agree Slightly</td>
<td>Agree</td>
<td>Agree Strongly</td>
<td></td>
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<td>3</td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>It just doesn't pay to try hard, since things never turn out right anyway.</td>
<td>Disagree Strongly</td>
<td>Disagree</td>
<td>Disagree Slightly</td>
<td>Agree Slightly</td>
<td>Agree</td>
<td>Agree Strongly</td>
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<td>1</td>
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<td>3</td>
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</tr>
<tr>
<td>19.</td>
<td>I enjoy being with people who are unpredictable.</td>
<td>Disagree Strongly</td>
<td>Disagree</td>
<td>Disagree Slightly</td>
<td>Agree Slightly</td>
<td>Agree</td>
<td>Agree Strongly</td>
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<td>-3</td>
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<td>3</td>
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</tr>
<tr>
<td>20.</td>
<td>It bothers me when something unexpected interrupts my daily routine.</td>
<td>Disagree Strongly</td>
<td>Disagree</td>
<td>Disagree Slightly</td>
<td>Agree Slightly</td>
<td>Agree</td>
<td>Agree Strongly</td>
<td></td>
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</tr>
<tr>
<td>21.</td>
<td>When I make a mistake, there's little I can do to make things right again.</td>
<td>Disagree Strongly</td>
<td>Disagree</td>
<td>Disagree Slightly</td>
<td>Agree Slightly</td>
<td>Agree</td>
<td>Agree Strongly</td>
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</tr>
<tr>
<td>22.</td>
<td>I respect rules, because they guide me.</td>
<td>Disagree Strongly</td>
<td>Disagree</td>
<td>Disagree Slightly</td>
<td>Agree Slightly</td>
<td>Agree</td>
<td>Agree Strongly</td>
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<td>3</td>
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</tr>
<tr>
<td>23.</td>
<td>One of the best ways to handle problems is just not to think about them.</td>
<td>Disagree Strongly</td>
<td>Disagree</td>
<td>Disagree Slightly</td>
<td>Agree Slightly</td>
<td>Agree</td>
<td>Agree Strongly</td>
<td></td>
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<td>-3</td>
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<td>-1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>24.</td>
<td>I believe that athletes are just born good at sports.</td>
<td>Disagree Strongly</td>
<td>Disagree</td>
<td>Disagree Slightly</td>
<td>Agree Slightly</td>
<td>Agree</td>
<td>Agree Strongly</td>
<td></td>
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<td>-3</td>
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<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>I don't like things to be uncertain or unpredictable.</td>
<td>Disagree Strongly</td>
<td>Disagree</td>
<td>Disagree Slightly</td>
<td>Agree Slightly</td>
<td>Agree</td>
<td>Agree Strongly</td>
<td></td>
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<td></td>
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<td>-3</td>
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<td>-1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>26.</td>
<td>My life gets wasted doing things that don't mean anything.</td>
<td>Disagree Strongly</td>
<td>Disagree</td>
<td>Disagree Slightly</td>
<td>Agree Slightly</td>
<td>Agree</td>
<td>Agree Strongly</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>-3</td>
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<td>-1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>27.</td>
<td>I don't really know my own mind.</td>
<td>Disagree Strongly</td>
<td>Disagree</td>
<td>Disagree Slightly</td>
<td>Agree Slightly</td>
<td>Agree</td>
<td>Agree Strongly</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-3</td>
<td>-2</td>
<td>-1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>28.</td>
<td>I have no use for theories that are not closely tied to the facts.</td>
<td>Disagree Strongly</td>
<td>Disagree</td>
<td>Disagree Slightly</td>
<td>Agree Slightly</td>
<td>Agree</td>
<td>Agree Strongly</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-3</td>
<td>-2</td>
<td>-1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>29.</td>
<td>Ordinary work is just too boring to be worth doing.</td>
<td>Disagree Strongly</td>
<td>Disagree</td>
<td>Disagree Slightly</td>
<td>Agree Slightly</td>
<td>Agree</td>
<td>Agree Strongly</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-3</td>
<td>-2</td>
<td>-1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
30. When other people get angry at me, it's for no good reason. -3  -2  -1  1  2  3

31. Changes in routine bother me. -3  -2  -1  1  2  3

32. I find it hard to believe people who tell me the work they do is of value to society. -3  -2  -1  1  2  3

33. I feel that if someone tries to hurt me, there's not much I can do to try to stop them. -3  -2  -1  1  2  3

34. Life just isn't very exciting for me. -3  -2  -1  1  2  3

35. I like variety in my paid work* -3  -2  -1  1  2  3

---

*if you do not hold a paid job, please answer these questions in terms of previous work experience, school or your general vocation in life.
Scoring Instructions for the Personality Hardiness Scale

Challenge Items = 5, 8, 14, 19, 20, 22, 25, 28, 31, 34, 35.

Commitment Items = 1, 2, 7, 9, 11, 13, 15, 17, 26, 27, 29, 32.

Control Items = 3, 4, 6, 10, 12, 16, 18, 21, 23, 24, 30, 33.

Items to be reversed = 2, 5 to 15, 18, 20 to 34.
APPENDIX D
SOCIAL SUPPORT TOOL

INTERPERSONAL RELATIONSHIP INVENTORY ©

Short Form

Virginia P. Tilden, DNSC, RN, FAAN
Department of Mental Health Nursing
Oregon Health Sciences University
3181 SW Sam Jackson Park Road
Portland, Oregon 97201
The short form of the IPRI consists of 26 Likert items, each scored from 1 to 5. Items yield two scores, one for support and one for conflict. Scale scores are derived by simple summation of item scores. Items from the scales are mixed in order to avoid response sets.

Definitions of the subscales and the items that comprise each follow:

SOCIAL SUPPORT: The perceived availability or enactment of helping behaviors by persons with whom one is engaged in relationships that are usually informal or non-contractual. 13 items; numbers 1, 2, 3, 4, 5, 7, 9, 10, 11, 13, 14, 15, 25.

CONFLICT: Perceived discord or stress in relationships is considered ubiquitous in social networks. Conflict can be occasional, periodic, or consistent, and can either be caused by behaviors of others actually enacted, or by the absence of behavior enacted by others, such as the withholding of supportive behaviors. 13 items; numbers 6, 8, 12, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26.

Conceptually, items required two different anchor styles. Items were clustered by perceived states and anchored with agree-disagree (those numbered 1 through 14), or by how often a behavior is enacted and anchored with often-never (those numbered 15 through 26). Thus the support subscale consists of 11 perceived and 2 enacted behaviors, and the conflict subscale consists of 3 perceived and 10 enacted behaviors.

Page 3 consists of a network list which yields a total number in the network and sources of support. Page 4 yields demographic data and two descriptive network items: the number of people living in the household and the number of important (close) relatives who live nearby.
**INTERPERSONAL RELATIONSHIP INVENTORY**

Test relationships with people we feel close to are both helpful and stressful. Below are statements that describe close personal relationships. Please read each statement and mark an X in the box that best fits your situation. There are no right or wrong answers.

These first statements ask you to disagree or agree.

<table>
<thead>
<tr>
<th></th>
<th>STRONGLY DISAGREE</th>
<th>DISAGREE</th>
<th>NEUTRAL</th>
<th>AGREE</th>
<th>STRONGLY AGREE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I know someone who makes me feel confident in myself</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>2.</td>
<td>Some people I care about share similar views with me.</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>3.</td>
<td>There is someone I can turn to for helpful advice about a problem.</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>4.</td>
<td>I can talk openly about anything with at least one person I care about.</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>5.</td>
<td>There is someone I could go to for anything.</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>6.</td>
<td>Some people in my life are too pushy.</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>7.</td>
<td>I can count on a friend to make me feel better when I need it.</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>8.</td>
<td>There is someone in my life who gets mad if we have different opinions.</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>9.</td>
<td>It's safe for me to reveal my weaknesses to someone I know.</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>10.</td>
<td>Someone I care about stands by me through good times and bad times.</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>11.</td>
<td>I have the kind of neighbors who really help out in an emergency.</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>12.</td>
<td>There is someone I care about that I can't count on.</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>13.</td>
<td>If I need help, all I have to do is ask.</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>14.</td>
<td>I have enough opportunity to talk things over with people I care about.</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
</tbody>
</table>
These next statements ask you how often something happens.

<table>
<thead>
<tr>
<th></th>
<th>NEVER</th>
<th>ALMOST NEVER</th>
<th>SOMETIMES</th>
<th>FAIRLY OFTEN</th>
<th>VERY OFTEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.</td>
<td>I have enjoyable times with people I care about</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>16.</td>
<td>I spend time doing things for others when I'd really rather not</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>17.</td>
<td>Some people I care about invade my privacy</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>18.</td>
<td>I am embarrassed by what someone I care about does</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>19.</td>
<td>Someone I care about tends to take advantage of me</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>20.</td>
<td>Some people I care about are a burden to me</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>21.</td>
<td>I wish some people I care about were more sensitive to my needs</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>22.</td>
<td>People I care about make me do things I don't want to do</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>23.</td>
<td>There is tension between me and someone I care about</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>24.</td>
<td>I have trouble pleasing some people I care about</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>25.</td>
<td>At least one person I care about lets me know they believe in me</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>26.</td>
<td>Some people I feel close to expect too much of me</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
</tbody>
</table>

Continue next page...
On the lines below, please list the people who are important to you, using only their first names or initials. For each person, state their relationship to you:

<table>
<thead>
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<th>EXAMPLE</th>
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<tbody>
<tr>
<td>Person</td>
<td>Relationship</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>YOUR LIST</th>
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<tbody>
<tr>
<td>Person</td>
<td>Relationship</td>
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</tbody>
</table>
**A Few Last Questions**

Age at last birthday: ____________________

Mark an X in the box that best describes you:

<table>
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<th>Gender:</th>
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<tbody>
<tr>
<td>Man</td>
<td>☐</td>
<td>1</td>
<td></td>
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<tr>
<td>Woman</td>
<td>☐</td>
<td>2</td>
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<table>
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<tr>
<th>Marital Status:</th>
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<tr>
<td>Single (Never married)</td>
<td>☐</td>
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<td></td>
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<tr>
<td>Partnered, not married</td>
<td>☐</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>☐</td>
<td>3</td>
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<td>Divorced or Separated</td>
<td>☐</td>
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<tr>
<td>Widowed</td>
<td>☐</td>
<td>5</td>
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</table>

Education: Years of regular school completed *(Check highest level completed only)*

<table>
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<tr>
<th>Grade Level:</th>
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<td>Grades 0 – 8</td>
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<td>Grades 9 – 11</td>
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<tr>
<td>High School</td>
<td>☐</td>
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<tr>
<td>Some College</td>
<td>☐</td>
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<td>College Graduate</td>
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<tr>
<td>Post-College Education</td>
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</table>

Race/Ethnicity:

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<tr>
<td>African American</td>
<td>☐</td>
<td>2</td>
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<tr>
<td>Hispanic</td>
<td>☐</td>
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<tr>
<td>Native American Indian</td>
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<tr>
<td>White</td>
<td>☐</td>
<td>5</td>
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<tr>
<td>Other</td>
<td>☐</td>
<td>6</td>
<td></td>
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<tr>
<td>Prefer not to answer</td>
<td>☐</td>
<td>7</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**How many people live with you in your household?  ____________

*(total number not including you)*

Employment:

<table>
<thead>
<tr>
<th>Employment:</th>
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**How many of your close relatives live within 50 miles of you?  ____________

*(total number including those living with you)*

Thank you for your participation.
APPENDIX E

PATIENT CONSENT TO PARTICIPATE IN RESEARCH

Nutritional Status, Personality Hardiness, Social Support of the Elderly Related to Acute Hospital Length of Stay Following Non-Emergent Surgery

Sally A. Myers, R. N., M. S., Principal Investigator
The Queen's Medical Center, Honolulu, Hawaii
Phone Numbers: 547-4429 or 547-4645
Phone Number: 235-0461 (home after 6 p.m.)

I, ________________________________, agree to take part in this study. This study will try to find out if my nutritional health, my own personality style, and the support of my family and friends after surgery make a difference in how well I do.

On a day before surgery, nurses will give me tests for about 2 to 2 1/2 hours. I may have to make a special trip to the hospital for these tests. I may bring someone with me. Nurses on the study team will ask me questions about my family and my health. Three questionnaires about me will be completed with help from a nurse if needed. Blood specimens will be taken for routine tests. About a tablespoon of extra blood will be taken for special tests. These blood test results will be given to my doctor and will be placed on my hospital chart before surgery. I will take a breathing test and will
have measurements (height, weight, arm measurements, grip strength, fat-fold measurements, etc.) taken to check my nutritional fitness. The study team will not do any test that will cause me harm. Any test which is only being done for the study will be paid for by the study. The only risk of answering the questions may be emotional distress and a possible loss of privacy.

While I am in the hospital, the study team will visit me and review my medical record to see how well I do during and after surgery. All of the information about my family and me will be kept safe and will be used only by the study team.

This study may not do me any good, but it may give information on how to help other older patients do better when they have surgery. I may ask any questions about anything during the study period, and I may withdraw from the study at any time without making any difference in the care that I will receive.

I certify that I have read and that I understand the foregoing, that I have been given satisfactory answers to my inquiries concerning project procedures and other matters and that I have been advised that I am free to withdraw my consent and to discontinue participation in the project or activity at any time without prejudice.

I herewith give my consent to participate or I consent to the participation of my adult ward in this project with the understanding that such consent does not waive any of my legal rights, nor does it release the principal investigator or the institution or any employee or agent thereof from liability for negligence.
1. Patient/Subject's Name __________ Signature of participant __________ Date

2. ___________ ___________ ___________
   Guardian's Name* Signature Date

*Obtain name and signature of guardian or legally authorized representative if subject is mentally unable to understand.

3. ___________ ___________ ___________
   Researcher's Name or Signature Date
   Researcher's Representative

If you cannot obtain satisfactory answers to your questions or have comments or complaints about your treatment in this study, contact:

Research and Institutional Review Committee
The Queen's Medical Center
1301 Punchbowl Street
Honolulu, Hawaii 96813
Phone: (808) 538-9011, Ext. 4512

or call:

Committee on Human Studies, University of Hawaii
2540 Maile Way
Honolulu, Hawaii 96822
Phone: 808-956-8658

CC: Unsigned copy to subjects

Flesch Reading Score: 65.4 (Fairly Easy)
Grade Level Required: 8
Understood by: 88% of U.S. Adults
Flesch-Kincaid grade level: 8.3
Gunning Fog Index: 11.1
REFERENCES


complications in patients with fractures of the hip. *Journal of Orthopaedic Trauma, 4*(1), 49-57.


Schmidt, R. T., & Toews, J. V. Grip strength as measured by the Jamar dynamometer. *Archives of Physical Medicine and Rehabilitation, 51*, 321-327.


