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THE EXPLORATION AND DEVELOPMENT OF A CAUSAL MODEL FOR ASTHMA MORBIDITY BY CONFIRMATORY FACTOR ANALYSIS AND PATH ANALYSIS UTILIZING COMMON CLINICAL VARIABLES

presented by

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has been accepted towards fulfillment
of the requirements for the

M.S. degree in Epidemiology

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April 13TH, 2007
Date

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Epidemiology

2007

ABSTRACT

THE EXPLORATION AND DEVELOPMENT OF A CAUSAL MODEL FOR ASTHMA MORBIDITY BY CONFIRMATORY FACTOR ANALYSIS AND PATH ANALYSIS UTILIZING COMMON CLINICAL VARIABLES

By

Thomas Paul Miller

The current study is an attempt to develop a causal model for asthma morbidity incorporating current symptom severity, quality of care indicators, and previous severe disease as explanatory variables. The study population consists of children who presented to an emergency department for asthma. Data was obtained from four survey instruments. The data included demographic information, as well as information regarding asthma history, current symptoms and treatment, medical management, as well as healthcare seeking behaviors and asthma care since the index visit including urgent care. All observed variables were assigned to one of the latent variable categories and then subjected to confirmatory factor analysis (CFA) and path analysis (PA) to develop the causal model. The presence of severe current symptoms and previous severe disease were significantly related to high quality of care, however, the only factor (latent variable) that was significantly related to six month morbidity was prior severe disease.

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KEY TO ABBREVIATIONS

ACT: Asthma control test

AD: Age at diagnosis

AS: Asthma specialist

ASTHED: Asthma education

CDF: Clinical data form

CFA: Confirmatory factor analysis

CFI: Comparative fit index

df: Degrees of freedom

ECRHS: European Community respiratory Health Study

ED: Emergency department

EDE: ED visit ever

FAL: Frequency of activity limitation

FDS: Frequency of daytime symptoms

FEV1: Forced expiratory volume in 1 second

FNS: Frequency of nocturnal symptoms

FVC: Forced vital capacity

GINA: Global Initiative for Asthma

HE: Hospitalization ever

HEDIS: Health Plan Employer Data and Information Set

HRQOL: Health related quality of life

ICS: Inhaled corticosteroids

NAEPP: National Asthma Education and Prevention Program

NCQA: National Committee for Quality Assurance

NHIS: National Health Interview Survey

NNFI: Non-normed fit index

PA: Path analysis

PCP: Primary care physician

PEF: Peak expiratory flow

PFMTR: Peak flow meter

QOL: Quality of life

RMSEA: Root mean square error of approximation

SEM: Structural equation modeling

SMED: Six month emergency department visit

SMF: Six month follow up form

SMH: Six month hospitalization

SMUC: Six month urgent care visit

TCRS: Tucson Children's Respiratory Study

TWF: Two week follow up form

UK: United Kingdom

SF: Severe flare

SE: Oral or injectable steroids ever

SES: Socioeconomic status

SP: Spacer

WAP: Written action plan

Chapter 1: Background

Introduction

One of the most common goals in the treatment of most diseases is to prevent future morbidity. In general this is done by first determining the relative stage or severity of the disease and then outlining a treatment strategy that is expected to decrease disease activity and future morbidity. The effectiveness of the treatment strategy is dependent upon many factors; some of which are disease specific while others are not. Factors that are disease specific for asthma could include the degree of airflow obstruction, allergic phenotype, or the relative responsiveness to steroids. Factors that are not disease specific could include socioeconomic status or psychosocial factors that may impact adherence. All of these factors together form the context of disease. It is desirable to attempt to incorporate the entire context of disease in analyses to determine how these various factors interrelate as well as cause specific outcomes. By doing this, we will not only have a better understanding of the disease itself, but also develop a more accurate causal model for morbidity. Most risk models tend to be reductionistic in philosophy i.e. what are the fewest observed variables that are associated most strongly with the outcome of interest? This can be very beneficial if we wish to identify a few easily determined risk factors which if modified can alter future risk (ex. cholesterol level or tobacco use). With this type of approach, however, we will never truly be able to develop causal models that explain the complex interplay between genetic predisposition, environmental exposures, host responses, disease development, and disease progression. It will only be when we incorporate the entire

context of disease that the complex clinical reality will begin to be defined. Incorporating the entire context of disease, however, is difficult because of the potentially infinite number of variables that could impact disease control or future morbidity. The potential for collinear associations between variables also complicates the analysis. It is desirable to categorize observed variables into groupings of like variables for analysis purposes, yet include variables from the major clinically relevant categories. Thus, this type of approach can be thought of as expansive, in that it is an attempt to incorporate the entire context of disease, yet reductionistic in the sense that these variables will be grouped into like groupings that likely represent underlying constructs. Only by describing clinical disease in this way will we begin to develop models that reflect the entirety of the patient, disease experience.

The current study is an attempt to develop a causal model for asthma morbidity using confirmatory factor analysis (CFA) followed by path analysis (PA) that incorporates major elements of the context of disease applied to a clinical data set. Relevant components of the context of disease will be identified from the asthma morbidity risk assessment literature. They will be organized into categories that likely represent the underlying theoretic constructs (latent variables) that lead to the variables that we observe. The clinical data set will then be analyzed by assigning the observed variables from the data set to corresponding latent variable categories. The application of this approach to a clinical data set will allow the development of a model that reflects the clinical reality of asthma morbidity risk assessment that is employed in clinics and offices. This approach will also lessen some of the statistical challenges dealing with collinearity that can be a problem with multivariable analysis. The current

study, by utilizing longitudinal data from an emergency department (ED) cohort of asthmatic patients, will determine the latent variable model by using confirmatory factor analysis and will develop a causal model for asthma morbidity by using path analysis. The model will consist of four latent variables (see figure 1) including current symptom severity, quality of care indicators, and previous severe disease, which are regarded as explanatory variables, and six month morbidity which is the composite outcome or dependent variable.

What is a latent variable?

In their text *Generalized Latent Variable Modeling: multilevel, longitudinal, and structural equation models*, Skrondal and Rabe-Hesketh define a latent variable "as a random variable whose realizations are hidden from us...in contrast to manifest variables where the realizations are observed." Though latent variable modeling is perhaps most commonly applied in the fields of psychology and the social sciences, Skrondal and Rabe-Hesketh note that latent variables pervade modern statistics and are also being applied in areas of medicine, economics, engineering, marketing, and biology. Though their definition of latent variables may seem simple, the application of the concept is not. Skrondal and Rabe-Hesketh go on to describe the use of latent variables to represent a variety of different concepts including the measurement of a 'true' variable measured with error, hypothetical constructs, unobserved heterogeneity, missing data, or other phenomena. In this study, latent variables are considered as the underlying constructs whose manifestations are the observed variables that can be measured.

Asthma is a complex syndrome with many clinical presentations in adults and children. The cardinal characteristics of asthma include airway inflammation, a variable degree of airflow obstruction, and bronchial hyperresponsiveness (1). The Expert Panel Report responsible for setting clinical guidelines (2) defined asthma as a chronic inflammatory disorder of the airways in which many cells and cellular elements play a role, in particular, mast cells, eosinophils, T lymphocytes, neutrophils, and epithelial cells. In susceptible individuals, this inflammation causes recurrent episodes of wheezing, breathlessness, chest tightness, and cough, particularly at night and in the early morning. These episodes are usually associated with widespread but variable airflow obstruction that is often reversible either spontaneously or with treatment. The airway inflammation results in an increase in the existing bronchial hyperresponsiveness to a variety of stimuli. This definition of asthma was reaffirmed in the 2002 Expert Panel Report Update, though the concept of asthma was expanded to include airway remodeling (irreversible obstruction) in some patients (3). Besides the themes of airflow obstruction, airway inflammation and hyperresponsiveness, these definitions emphasize the variable nature of asthma, which may be a reflection of the various etiologic factors that can contribute to asthma. Asthma is frequently a manifestation of allergic disease, thus the development of asthma is closely linked to the development of allergic sensitization.

Asthma prevalence in the United States has been tracked by the National Health Interview Survey (NHIS). From 1980 until 1996 the NHIS determined asthma prevalence rates based on a self-reported asthma episode in the preceding 12 months. Starting in 1997 a second question reflecting lifetime prevalence was added (though

this question is termed 'current asthma'). Prevalence increased through much of the 1980's and early 1990's, (4) however, these prevalence rates (asthma episode in the preceding 12 months) have been fairly constant since 1997 ranging from 3.9% (1999) to 4.3% (2002) with the most recent figure of 4.2% in 2005 (5). The asthma episode prevalence rate in young children is higher than older age groups; in 2005 the rate among children aged 0-14 years was 5.4% (6.4% in males and 4.3% in females), compared to 4.1% in those aged 15-34 years (2.8% in males and 5.5% in females), and 3.8% in those over 34 years (2.5% in males and 5.0% in females).

Prevalence differences by race were also observed. Asthma episodes in the last 12 months and current asthma prevalence rates in the 0-14 year age group were highest in non-Hispanic Black children (6.7%, 13.6% respectively), compared to Hispanic children (5.4%, 9.2%) and White non-Hispanic children (4.8%, 7.5%). Current asthma prevalence in the 15 years and over age group was highest in non-Hispanic Black individuals (8.4%), compared to non-Hispanic White (7.7%) and Hispanic (5.3%) individuals. In the 15 years and over, age group, for an asthma episode in the last 12 months, the highest rate was observed in the non-Hispanic White group (4.1%) compared to non-Hispanic Black (3.7%) and Hispanic (3.0%) groups.

Asthma morbidity, as measured by healthcare utilization, in children is substantial. In 2003 there were 4.6 million ambulatory visits to office-based physicians or hospital clinics for asthma in children aged 3 – 17 years in the United States. During the same year there were 475,000 ED visits and 132,000 hospitalizations for asthma in the same age group. Just as prevalence rates are highest in the younger age groups, hospitalization rates are also higher. Even though the younger group (aged 3-10 years)

made up approximately 50% of the individuals in the 3-17 years age group, approximately 70% of the hospitalizations for asthma occurred in this younger age group (6).

Simplistically, the development of asthma can be conceptualized as occurring in a genetically susceptible individual after sufficient environmental exposures. However, the reality of this simplistic concept is extremely complex. Twin studies have demonstrated the importance of genetic factors (7-9). There have been hundreds of genetic association studies evaluating asthma related phenotypes in various populations (10). The results of these studies suggest that there is no single "asthma gene" and the high level of heterogeneity at a genetic level plays a significant role in the heterogeneity observed clinically.

The complexity of gene-environment interactions is also implicated by the heterogeneity of exposures that play a role in the development of asthma. Studies of early childhood exposures have led to the "hygiene hypothesis" which has suggested that a cleaner early childhood environment including less exposure to other children and fewer infections has led to an increase in the incidence of allergic diseases and asthma. The association between increased infections and decreased risk for allergic rhinitis, eczema, and elevated circulating IgE levels has been demonstrated, however, the association with asthma is less clear (11-14).

The natural history of asthma has been observed in a few well-designed longitudinal studies. Perhaps the most widely recognized is the Tucson Children's Respiratory Study (TCRS) which began is 1980 with a birth cohort and continues today (15). In this cohort approximately one third of the children experienced wheezing

during a lower respiratory tract infection at some point during the first year of life. This risk declined in subsequent years, however, approximately 41% of children who wheeze with infections during the first few years of life will develop persistent wheezing (wheezing at age 6 years). This risk of developing persistent wheezing, is increased if the children have a family history of asthma or have evidence of allergic disease (examples include atopic dermatitis, eosinophilia, or high IgE levels). The risk of transient and persistent wheezing is increased with environmental tobacco smoke exposure as well.

The diagnosis of asthma typically includes three components: the presence of episodic symptoms reflective of airflow obstruction, demonstration of airflow obstruction that is at least partially reversible, and exclusion of alternative diagnoses (2). The goal of pharmacologic therapy is to prevent or control asthma symptoms, reduce the frequency and severity of exacerbations, and decrease airflow obstruction. This is done by utilizing long-term control medications on a daily basis and utilizing symptom relief medications (beta agonsits) as needed. The most effective long-term control medications are the inhaled steroids as they are able to decrease airway inflammation better than any other single medication. Asthma treatment requires a comprehensive approach that involves determining the severity of disease, adjusting the type, number and dose of medications accordingly, and developing a partnership with patients to promote education and patient self-management. Even with our increasing knowledge of asthma pathophysiology and pharmacology, asthma education and self monitoring techniques, asthma patients continue to experience severe exacerbations resulting in urgent care visits, emergency department (ED) visits, hospitalizations, or

even death. There is a large literature devoted to the exploration of risk factors for asthma morbidity and mortality.

Proposed theoretical model

There is a large literature that has identified individual factors that are associated with an increased risk for asthma morbidity (16-61). These observed variables likely represent the underlying latent variables mentioned above (current disease control, quality of care, and previous severe disease). The following is a description of the literature supporting these proposed latent variable groupings. These descriptions are of those variables that could be included in each specific group, however, not all these variables were available from the data we utilized in this study. Observed variables reflecting socioeconomic status or psychosocial factors were not adequately represented in the data set. These factors will therefore not be included in the model; however, these factors should be included in future models. These factors are mentioned below because the literature supports including them in risk models. This will be discussed in the discussion section.

1. Current symptom severity. Defining asthma severity has been the subject of much discussion over the last few years (16-25). The distinction between severity and control is at times ill-defined. The National Asthma Education and Prevention Program (NAEPP) guidelines were first published in 1991 (26) with a second expert panel report published in 1997 (2). These guidelines suggested a severity based classification system (i.e., mild intermittent, mild persistent, moderate persistent, and severe persistent) for asthma with stepwise treatment recommendations based on the given

severity level. This severity classification was based on the presence and frequency of current symptoms, exercise intolerance, nocturnal symptoms, as well as measures of pulmonary function (peak expiratory flow or forced expiratory volume in 1 second). This severity classification system should be determined based on clinical features before treatment and is therefore difficult to implement, as most patients are receiving varying levels of therapy. This classification system shares many components with what we now would consider measures of current disease control, which is also based on current symptoms (27-29). The level of current symptoms is greatly influenced by both the underlying disease severity as well as the level of medication utilized. For example, a given patient with severe disease may require very high levels of inhaled steroids in combination with a long acting bronchodilator. This patient may in fact have very good disease control with this aggressive regimen; however, this masks the fact that this individual has severe asthma. Because of the overlap between the concepts of disease severity and disease control we included both in one latent variable category. Specifically, in this category we will include level and frequency of current symptoms, level of pulmonary function, and current medication requirements. The literature supporting the association between increased disease severity or decreased disease control and increased risk for future asthma morbidity is well established (30-32) and includes factors such as increased symptom severity, frequency (30-32), decreased FEV1 (33,34), increased B agonist use (31,35,36), or the use of oral steroids (33-35,37).

2. Quality of care indicators. The following quality of care indicators are based on our interpretation of the NAEPP Expert Panel Report 2 (2). These quality indicators

include: (1) at least two scheduled appointments with an asthma care provider in the last year, (2) access to and use of a spacer if age appropriate, (3) access to and use of a peak flow meter if age appropriate, (4) presence of a long term control medicine for persistent asthmatics, (5) access to and use of a written asthma action plan, (6) asthma education regarding self-management, (7) referral to an asthma specialist for moderate to severe persistent asthma, and (8) timely follow-up with an asthma care provider after ED visit. The literature supporting the association between poorer quality of care and increased asthma morbidity includes not having a personal physician (35), no action plan (31,36,37), not using a controller such as cromolyn (35,38,40) or an inhaled steroid (38,41-43) low ICS to B agonist ratio (44), or having a large number of prescribers (35). We include these measures as indicators of the quality of care even though, as pointed out in the 2002 Expert Panel Report Update (3), data are insufficient to support or refute some of these specific interventions (ex. peak flow versus symptom monitoring only).

3. Previous severe disease. Previous healthcare utilization will be included and defined as an ED visit or hospitalization (with or without intensive care unit care). Previous utilization has been one of the most consistent risk factors for future morbidity. This includes previous ED visits (30,31,35,36,46,47), previous hospitalizations (34,35,37,48-50), recent outpatient asthma visits (30,32,50), including unscheduled asthma visits (30). Since the presence of asthma at a younger age has been shown to reflect increased severity of disease as defined by increased hospitalization rates or ED visits (30,35,44), age at diagnosis will be included in this category. As the need for oral or injectable steroids reflects a more severe asthma flair,

the presence of the previous need for oral or injectable steroids will also be included in this category.

Socioeconomic status and psychosocial functioning represents a separate category. This category is broad and may contain the most diverse group of factors, however, for some individuals, these factors may be the most important. This category includes demographic factors shown to be associated with increased asthma morbidity, such as gender (51-53) and ethnicity (44,54-56). Socioeconomic factors such as income or poverty status (31,44,54), educational level (44,54), insurance status (48,57) are included. Behavioral issues whether smoking (58), illicit drug use (59), psychiatric factors (42,60), lack of social support (32), crowding (54) or language barrier (61) have also been associated with increased asthma morbidity.

Current Risk Models

There is overlap in the concepts of severity assessment, determination of disease control, and morbidity risk stratification. As mentioned above, the NAEPP recommendations for severity classification are more consistent with what we would now consider measures of disease control (based on current daytime and nighttime symptoms, as well as current pulmonary function). The Global Initiative for Asthma (GINA) was launched in 1993 by worldwide leaders in asthma care in collaboration with the National Heart, Lung, and Blood Institute, National Institutes of Health, USA, and the World Health Organization. GINA guidelines (62) suggest current medications be considered along with current symptoms and pulmonary function to determine severity. A more formal tool used to determine current disease control is the Asthma

Control Test (ACT) (63). This 5-question survey determines the frequency during the past 4 weeks of shortness of breath, nighttime awakenings, beta agonist use, and activity limitation. The last question regards self-rated asthma control (How would you rate your asthma control in the last 4 weeks?). The ACT, like the NAEPP and GINA severity classification guidelines, is mainly influenced by the level of current symptoms. The only difference is that the ACT asks about self-rated control, whereas NAEPP and GINA incorporate pulmonary function, and GINA considers current medications. These tools can essentially be considered as clinical risk stratification instruments as they identify patients who are judged to have more severe disease (NAEPP and GINA) or poor disease control (ACT) in whom increased therapy is expected to decrease disease activity and future morbidity.

Various other risk assessment models have been proposed that incorporate additional information (33-35,46,49,50,64-69). These models may be based on clinical information obtained from patients, administrative data obtained from a computer database, or a combination, and typically include data on demographics, socioeconomic status, asthma symptoms, past healthcare resource utilization, medication usage, elements of the treatment program (ex. asthma education), or comorbid conditions. A variety of analytic techniques are used to identify risk factors or high risk groups, including multivariate regression techniques, factor analysis, or recursive partitioning (classification tree) techniques, although most commonly univariate analysis followed by multivariable logistic regression is used. Our latent variable model and casual path analysis differs from these risk stratification tools or risk assessment models in that we are attempting to describe the underlying constructs and not the observed variables

themselves, and determine how these factors (constructs) interrelate and lead to increased morbidity as opposed to develop a clinical classification system based on the observed variables and applied to individual patients. Risk assessments models may reveal if a given factor is associated with an outcome, however, it does not reveal how or why the factor is associated with increased risk. Reviewing existing risk assessment models in addition to the clinical measures of severity or control mentioned above, can offer insight into the types of observed variables that should be included in the latent variable structure of our study.

Risk assessment models were evaluated as background, for the latent variable structure of this study that incorporated a divergent group of independent variables in an attempt to predict future morbidity. An example of a clinical risk assessment model is one developed by Li et al (34) who incorporated historical information as well as clinical measures of current disease control into a risk stratification model to predict hospitalization. Stepwise logistic regression and recursive partitioning were employed for model determination. The authors found an increased risk of subsequent hospitalization was associated with a hospitalization in the last year, moderate to severe respiratory impairment based on spirometry, severe disease based on medication regimen, the need for systemic steroids in the prior year, overnight PEF variability > 40%, or evening PEF value < 60%.

An example of utilizing electronic information in an attempt to assess risk of future morbidity involves the use of the Health Plan Employer Data and Information Set (HEDIS). This data set was developed by the National Committee for Quality Assurance (NCQA) to evaluate health plans. Based on electronic claims, this data set

tracks the proportion of persistent asthmatic patients who fill long-term controller prescriptions. This information was recently used to predict asthma related utilization outcomes (70). The researchers found that patients with low adherence to controller medication had the highest risk of ED visit or hospitalization. In an effort to increase the clinical application of risk assessment strategies utilizing information from an electronic database, Schatz et al (64) developed a clinical prediction rule. The researchers utilized an administrative database to develop a clinically useful prediction rule to identify patients who were at risk of subsequent hospitalization. Logistic regression modeling revealed that independent predictors of subsequent asthma hospitalizations in children included younger age, increased number of prior year hospitalizations, the number of beta agonist dispensings, and increased number of prescribing providers. The authors found that increased anti-inflammatory treatment was associated with a decreased risk of hospitalization. The model was able to identify about half the patients who required a hospitalization and was most useful in identifying subjects who were at low risk. Some authors have added generic and disease specific measures of health related quality of life (HRQOL) to the models or psychometric instruments (66,71,72). Though adding these dimensions likely more accurately reflected what patients were experiencing, the relative predictive value was similar to previous studies.

The current study, attempting to develop a causal model for asthma morbidity, may seem similar to previous asthma morbidity risk assessment models or analyses that utilize factor analysis (reviewed below). The most important distinction is the use of a latent variable framework. To our knowledge the use of confirmatory factor analysis to

establish the measurement model (define the fit of the latent variable model to the data), followed by path analysis to suggest a causal model for asthma morbidity has never been done previously. The fact that the latent variable groupings are an attempt to reflect the entire context of disease is also novel. Reviewing current asthma risk models as well as uses of factor analysis in asthma are appropriate background information for our approach.

What is factor analysis?

Factor analysis techniques, such as used in this study, can be confusing for the average clinician. Factor analysis techniques have been used for many years in the development and evaluation of psychological measures (73). These techniques are being increasingly applied to other areas of clinical medicine. Factor analysis can be divided into exploratory or confirmatory techniques depending on the extent of knowledge that currently exists regarding underlying causes or constructs. Confirmatory factor analysis is a distinct technique, which was used in this analysis. In factor analysis the covariance of the observed variables is assumed to be due to the causal influence of underlying latent variables (or factors) on the observed variables. This assumption is not made in a related statistical technique termed principle component analysis, which simply reduces the number of variables into components that explain most of the observed variance. Therefore, to identify the factor structure (latent constructs) underlying a data set, exploratory factor analysis would be employed, whereas, to simply reduce the data to the fewest components that explain most of the observed variance, principle component analysis would be employed

(though exploratory factor analysis will also reduce the number of variables). Exploratory factor analysis is used if the investigator desires to define the number and nature of the underlying latent variables, but has no previous knowledge (based on research or theory) as to what these underlying latent variables (constructs) should consist of. If there is a basis for suspecting what the underlying latent variables might consist of, then confirmatory factor analysis can be utilized (74). Confirmatory factor analysis is used to develop a measurement model which describes the relationships between the latent variables and the observed variables. This measurement model consists of the theoretic underlying latent variables and the observed variables that are presumed manifestations of the specific latent variable. Testing the measurement model will determine whether the observed (indicator) variables are truly measuring the underlying latent variable (construct) of interest, and whether the measurement model has an acceptable fit to the data. With confirmatory factor analysis all the latent variables are allowed to covary with each other, so no causal assumptions can be made. However, once the measurement model has been demonstrated to have an acceptable fit to the data, then a path analysis can be pursued to demonstrate the presence of causal relationships between latent variables. Path analysis is the technique utilized in the development of the structural model that specifies the causal relationships between the latent constructs themselves. This is done by specifying causal relationships between the latent variables that were significantly associated with each other in the measurement model, and consistent with postulated causal relationships (as opposed to confirmatory factor analysis in which all latent variables are allowed to covary in the measurement model and no causal relationships are postulated). Other names for path

analysis modeling could include structural equation modeling, covariance structure modeling or latent variable modeling. This two-step approach of confirmatory factor analysis followed by path analysis was the approach taken in the current study.

Factor Analysis in Asthma Research

Factor analysis techniques have been employed with increasing frequency in asthma research over the last decade. In general, these techniques are employed to validate survey instruments, determine whether a specific underlying construct is associated with a specific outcome, or determine the factor structure or common source of variance for observed variables. However, none have attempted to account for the entire context of disease and determine a causal model for asthma morbidity as we are doing.

Factor analysis is perhaps most commonly used in asthma research to determine the underlying factor structure or source of common variance for various observed variables. Rosi et al (75) sought to determine the separate dimensions of chronic asthma in clinically stable patients. Factor analysis was applied to various measures of airway obstruction, bronchial hyperreactivity, sputum eosinophils and eosinophilic cationic protein. The analysis yielded 3 independent factors representing airway function, bronchial hyperreactivity, and sputum results. Grazzini et al (76) utilizing similar methods sought to determine whether measures of lung function, sensation of dyspnea, respiratory muscle strength, and exertional capacity would reduce to similar or different factors. The authors found that 3 factors accounted for 78% of the observed variance. Measures of airway obstruction (FEV1, FVC) loaded on factor 1, respiratory

muscle strength, FRC, and exertional capacity loaded on factor 2, and dyspnea loaded on factor 3. Juniper et al (72) determined the factor structure underlying overall asthma health status which included measures of quality of life (QOL) and conventional clinical measures. The authors found that overall asthma health status consisted of 4 components: asthma specific QOL, airway caliber, daytime symptoms and beta agonist use, and nighttime symptoms and beta agonist use. Leung et al (77) sought to determine whether lung function parameters, atopy, exhaled nitric oxide, and airway inflammatory markers represent separate dimensions by principle component analysis in chronic stable pediatric asthmatic patients. The authors found that atopy and airway inflammatory indices are separate dimensions in assessment of chronic asthma. Interestingly, they also found that inflammatory markers in peripheral blood and exhaled breath condensate are non-overlapping factors. Schatz et al (66) sought to evaluate the relationships between various validated survey instruments measuring QOL, asthma control, symptom severity, self described severity, control and course over time, and history of acute exacerbations. Principle component analysis resulted in a 5 factor model which explained 59% of the observed variance. The authors, however, were unable to identify distinct constructs reflecting severity versus control.

The validation of asthma-related survey instruments has been a common area for the use of factor analysis. Sunyer et al (78) determined the cross-cultural validity of the European Community Respiratory Health Study (ECRHS) despite the fact that it was translated into multiple languages and applied in various countries and cultures. They initially identified the factor structure using exploratory factor analysis of questionnaire data collected in the United Kingdom (UK). Using this factor structure, a

confirmatory factor analysis was obtained using data from the other countries and languages to see if the factor structure identified in the UK was replicated by the data from the other countries. The authors found a high degree of internal consistency suggesting that the cross-cultural variations in reporting of symptoms had minimal impact. Schatz et al (79) used factor analysis to validate an asthma control scale based on beta agonist usage during the previous 12 months. The asthma control scale was significantly associated with validated measures of asthma symptom and control scales. Factor analysis was employed to determine construct validity, by showing that the asthma control scale loaded on the symptom and control factor.

Factor analysis can also be employed to determine whether an underlying construct is associated with a specific outcome. Fiese et al (80) initially determined the common source of variance of various surveys measuring asthma management routines, adherence, and quality of life by principle component analysis. The analysis revealed 2 dimensions, which the authors described as medication routines and routine burden. The medication routines dimension was significantly related to adherence and healthcare utilization, while the routine burden was significantly related to quality of life. Grus et al (81) sought to evaluate the association between parental self-efficacy and asthma morbidity. Parents completed a survey, which measured self-efficacy. Factor analysis of this instrument yielded 2 factors, learned helplessness and self-efficacy. The authors found that learned helplessness correlated with multiple measures of increased morbidity, whereas self-efficacy was associated with missed school only, suggesting that targeting parents who are experiencing high levels of perceived helplessness may be more helpful in an intervention program.

Fisher et al (82) utilized structural equation modeling (SEM) to determine whether a community-based intervention could improve asthma management practices and reduce the need for acute care. SEM was used to analyze the role of participation in the asthma coalition intervention within the context of other factors related to changes in acute care rates. The authors found that a high participation level in the intervention program was associated with a decline in acute care rates. The advantage of SEM was that the authors were able to determine the various relationships represented by the observed variables followed in the study.

Though most of these studies utilized an exploratory form of factor analysis and determined the specific relationship between an underlying construct and a specific outcome or determined the factor structure or common source of variance for observed variables, they have all been fairly narrow in focus. None has sought to categorize the entire context of disease to define how specific observed variables covary or group together to account for the entire context of disease.

If one summarizes the specific observed variables that were associated with increased morbidity from the risk assessment models, it is apparent that they seem to group in categories similar to those outlined above in the asthma risk literature. Grouping of risk factors is implied in treatment guidelines (2). In the initial diagnosis of asthma it is recommended that clinicians ask about symptoms in the last 12 months and also the last 4 weeks (thus categorizing chronic and recent symptoms). These recommendations also define asthma severity by current symptom and activity restriction, nighttime symptoms, and lung function thus categorizing severity assessment. Researchers reviewing the asthma risk literature have grouped observed

variables into many categories such as age/gender, race/ethnicity, socioeconomic, clinical, utilization, medication, and social/environmental (14) or few including history of previous severe attack, poor current disease control, and psychosocial factors compromising disease management (83). The current literature reflecting the application of factor analysis techniques to asthma does little to confirm or refute this type of organization. It is important, however, that like variables be grouped together for analysis purposes. The difficulties in dealing with large numbers of presumably independent variables in epidemiologic studies have been reviewed, with specific reference to the problem of collinearity (84). Thus, the categories defined by the clinical risk literature are supported by the risk assessment model literature. These categories reflect clinically relevant groupings of observed variables that are likely collinear. By grouping them together, the statistical problems associated with collinearity will be lessened (85,86). Therefore, since there is a theoretic basis for these latent variable groupings as discussed above as well as precedence for these groupings in previous risk models, confirmatory factor analysis can be appropriately utilized in this analysis. As the perspective of confirmatory factor analysis is theory driven, these groupings will serve as the basis for the latent variable model, which will then be tested to see if this theoretic model fits the data.

Prespecified hypothesis

Asthma risk stratification is a complex undertaking that will only be partially accurate until the entire context of disease is incorporated into the risk models. An

approach utilizing latent variables has the potential to incorporate the multiple dimensions that impact asthma morbidity.

Specific Aims

1. Use confirmatory factor analysis to apply a latent variable approach to risk stratification of asthma patients that incorporates a broader context of asthma.

2. Use path analysis modeling of the latent variables defined above to explore the magnitude and statistical significance of causal relationships between these latent variables.

3. Apply these techniques in a longitudinal cohort of asthmatic patients that will demonstrate a method that could be applied to other populations and different diseases.

Chapter 2: Methods

Study population

The study population consists of children who presented to 1 of 3 emergency departments for the evaluation and treatment of asthma during 2001. The original study was designed as a prospective cohort enrolling children aged 2-17 years who presented to an ED for evaluation and treatment of asthma at one of three western Michigan hospitals. The three hospitals represented urban, suburban, and rural locations. Children were eligible if they presented with signs and symptoms compatible with an acute asthma exacerbation (shortness of breath, coughing, wheezing, or chest tightness) and had a discharge diagnosis of asthma or had a previous diagnosis of asthma, reactive airways disease, or had filled a prescription for a bronchodilator in the past year. Patients were excluded if they had other significant illnesses or were hospitalized at the index visit. Children were enrolled by either trained research personnel or by respiratory therapists working at the rural hospital. The enrolled subjects represented a convenience sample of all asthma visits. Demographic characteristics are displayed in table 1 in the results section. More complete details of the child cohort patient population have been published elsewhere (87). In the original publication only two week follow up information was analyzed. In the current study six month follow up information was analyzed.

Data Collection

Data was obtained in the form of four survey instruments: clinical data form (CDF), child cohort visit form (CVF), two week follow-up form (TWF), and six month

follow-up form (SMF). Information for the CDF was obtained at the index visit from the medical record. The CDF contained information regarding the patient's initial presenting signs and symptoms as well as information regarding the evaluation and treatment received in the ED. Information for the CVF was obtained by a face to face interview with the parent or guardian at the index visit. The CVF contained demographic information, as well as information regarding asthma history, current symptoms and treatment, medical management, as well as healthcare seeking behaviors. Information for the two follow up forms was obtained by telephone interview with the parent or guardian. The follow-up forms contained information regarding asthma care since the index visit (including usual and urgent care, medical care, and current symptoms). The parent or guardian was asked whether urgent medical treatment had been required since the last information was obtained. They were asked where this urgent care was obtained, whether the child needed to be transferred to an ED or hospital, and whether the child was admitted to the hospital over night. These questions were the basis for determining whether the children needed urgent care, were seen in an ED, or were hospitalized. These forms are included in the appendix. In an effort to be inclusive, any observed variable (question) that reflected information that could be a component of the theoretic latent variable categories, as outlined above, was included unless the specific variable (or logical grouping of variables) was missing in 15% or more of the subjects. Subjects whose 6 month follow-up information was missing because of loss-to-follow-up (n = 31) were also eliminated from analysis leaving 166 subjects. Since the purpose of this study is to be clinically relevant all variables were characterized as to what would be considered high

risk or low risk. Most variables were dichotomous, however, the few that were not were converted to dichotomous at clinically relevant cut-off points if possible. These observed variables that were organized into the latent variables categories described in Chapter 1 (i.e., six month morbidity, current symptom severity, previous severe disease, and quality of care indicators). The latent variable representing the dependent or outcome variable in this study was six month morbidity. The independent (explanatory or exposure) variables in this study included the 3 latent variables labeled as current symptom severity, prior severe disease, and quality of care indicators.

Outcome and exposure variables (See table 2 for definitions of the observed variables in their latent variable categories and table 3 for description and distribution of all variables)

1. Six month morbidity. Three observed variables collected in the 6-month FU survey were used to define this latent variable. These three variables included urgent care visits (SMUC), ED visits (SMED), and hospitalizations (SMH) during the six month follow up. To increase the discrimination of this outcome these dichotomous variables were combined into one three level variable, which corresponded to no urgent care visits, one or more asthma-related urgent care visits that did not involve an ED visit or hospitalization (i.e., an unscheduled visit to a physician office), or one or more asthma-related ED visit or hospitalization during the 6 month follow-up.

2. Current symptom severity. The following observed variables were utilized as surrogates for the latent variable current symptoms. These variables were dichotomized into higher risk and lower risk. The cut-off values were chosen for these

variables based on the distinction between mild persistent and moderate persistent asthma as defined in the Expert Panel Report (2). Frequency of daytime symptoms (FDS), higher risk category was ≥3 times per week. Frequency of nocturnal symptoms (FNS), higher risk category was ≥3 times in the last 4 weeks. Frequency of activity limitation (FAL) higher risk category was ≥3 times in the last 4 weeks. Severe flare (SF) was defined as an asthma attack during the previous 4 weeks of sufficient severity where the child was only able to speak 1 or 2 words between breaths.

3. Previous severe disease. The following observed variables were utilized as surrogates for the latent variable previous severe disease. Age at diagnosis (AD) was considered higher risk if initial diagnosis of asthma was at 5 years of age or younger. Having received oral or injectable steroids ever (SE) resulted in a higher risk classification for this observed variable. Having an ED visit ever (EDE) or hospitalization ever (HE) resulted in a higher risk classification for these observed variables (EDE and HE). This grouping is utilized because previous severe disease is frequently the strongest predictor of future exacerbations (34,64).

4. Quality of care. The following observed variables were utilized as surrogates for the latent variable quality of care. Not utilizing an inhaled steroid (ICS), never having seen an asthma specialist (AS), never receiving a spacer (SP) or a peak flow meter (PFMTR), not having a written action plan (WAP) or receiving asthma education (ASTHED) were considered higher risk. These quality of care indicators are reflective of recommendations from the Expert Panel Report (2). They are included in this category even though it is likely that some individuals may have only been identified as being candidates for these interventions at the ED visit itself.

Statistics

Confirmatory factor analysis of the theoretically based latent variables (as defined above) is first used to develop a measurement model that demonstrates an acceptable fit to the data. Confirmatory factor analysis starts with theory to develop the model and then utilizes data to test the model, as opposed to exploratory factor analysis, which starts with data to develop the model, which is then used to develop the theory. More detailed discussions of the techniques employed in this study are available in references (73,74) or structural equation modeling textbooks (88). The measurement model is then modified to become the structural (causal) model by path analysis. This structural model is then tested and modified if necessary until it is theoretically meaningful and statistically acceptable. Correlations with standard deviations between all manifest (observed) variables are first determined using the SAS correlation (proc corr) procedure. The covariance structure model is analyzed with confirmatory factor analysis and then path analysis using the SAS CALIS (proc calis) procedure. Latent variables are indicated by at least three manifest variables. The two step approach is based in part on a method recommended by Anderson and Gerbing (89). The specific steps used to evaluate the measurement and structural model performance are explained below:

1. General fit of the model to the data. The measurement model describes the relationships between the latent variables themselves as well as the observed (manifest or indicator) variables that measure these latent variables. In the current study the

model consisted of four latent variables (or factors): current symptom severity (F2), quality of care indicators (F4), previous severe disease (F3), and six-month morbidity (F1). An overall model chi square value is determined for the initial measurement model using the maximal likelihood method. The null hypothesis is that the model fits the data. Because the chi square test is excessively sensitive, a chi square divided by the model degrees of freedom value is calculated and should be < 2, indicating the model may fit the data. Other fit indices are also reviewed including the non-normed fit index (NNFI) (90), the comparative fit index (CFI) (91) and root mean square error of approximation (RMSEA). These measure overall goodness of fit and are included in the SAS output though their derivation reflects a different perspective. Acceptable values for NNFI and CFI are > 0.95. The NNFI can be viewed simplistically as indicating the amount of covariance that is explained by the model compared to a model with no interrelationships between any of the variables. The RMSEA and CFI can be considered alternative fit indices as they operate on the perspective of the extent to which the model fails to fit the data (called the "noncentrality parameter"). A RMSEA value <0.05 can be considered as indicative of the model being a reasonable approximation to the analyzed data. The CFI can be thought of as a ratio of the improvement (or change) in noncentrality when moving from the null model (high noncentrality) to the proposed model (low noncentrality), over the null model (high noncentrality), therefore a high CFI (>0.95) is good while a low RMSEA (<0.05) is good even though both indices share the perspective of noncentrality (88). If these indices reveal that the model does not fit the data, then the next step would be

reviewing the specific factor loadings and the residual covariance matrix to determine why the fit is not good.

2. Review of specific variable or factor loadings and residual covariance matrix. When evaluating the specific factor loadings a non-significant factor loading indicates that the specific indicator (observed) variable is not doing a good job of measuring the underlying factor and perhaps should be reassigned to a different factor or dropped. In general factor loadings can be viewed as an indication of how much of the observed variance is caused by the underlying factor. Under certain conditions these loadings can be viewed as similar to regression or correlation coefficients. We first verify that there are no near zero standard errors. We then evaluate the t test results. The large sample t test of the null hypothesis, that the factor loadings are zero in the general population is used. A non-significant t test suggests that these variables could perhaps be dropped. The residual covariance represents the discrepancy between the predicted covariances based on the model and the actual observed covariances based on the data. We first observe the distribution of normalized residuals. A good fit results in a distribution that is centered on zero, symmetrical and contains no or few (<2) large residuals. Standardized residuals can be roughly interpreted as a z score, i.e. a value > 1.96 (or > 2.58) would correspond to a p value < 0.05 (or < 0.01). A large residual suggests that there is a large discrepancy between the predicted covariance between specific variables and the actual observed covariance between these variables. If the predicted covariance is much smaller than the actual covariance (yielding a positive standardized residual value), this suggests that the model underestimates the strength of the relationship between the variables. This usually (though not always) occurs when

the variables covary (are associated with each other) yet are modeled to represent different latent variables. A large negative standardized residual value suggests that the variables covary less than the model is predicting (the model overestimates the covariance). The rank order of the ten largest standardized residuals is displayed in the SAS output. Dropping any of these variables, with large residuals, from the measurement model would increase the fit of the model to the data, however, dropping as few as possible increases the construct validity and external validity of the model. It is also important to have at least three observed variables measuring each latent variable.

3. Modification indices. The Wald test, which is part of the standard SAS output indicates which variables, if dropped from the model would improve the fit the most (i.e. the Wald test simply lists which parameters if fixed to zero would increase the model fit the most). The Lagrange Multiplier test, which is also part of the standard SAS output, describes which variables or paths could be reassigned or added to improve the model fit (i.e. the LaGrange Multiplier test results in a list of parameters or pathways that, if added, would increase the model fit the most). It is important to be sure that alterations in the model recommended by the Wald or Lagrange Multiplier tests are theory driven and not strictly data driven.

The preceding three steps are applicable for confirmatory factor analysis as well as path analysis; however, there are differences in the initial assumptions for the models. Confirmatory factor analysis is done by allowing all the factors to covary. Path analysis, however, specifies a directionality in the relationships between the factors (latent variables), thus allowing a causal model to be theorized. This

directionality can be suggested by the results of the stepwise multivariate Wald test from the modified measurement model but should be consistent with clinical observations. The Wald test suggests not only individual variables that can be dropped from the model to improve fit, as mentioned above, but also suggests factor covariances that could be dropped to improve fit (such as if specific latent variables do not covary). Assuming that the model fits the data, the path equations are evaluated utilizing the factor loadings, standard error and t tests. This reveals the strength and impact of the specific factors. The R^2 value in path analysis is calculated for any endogenous (dependent) factor (latent variable). The R^2 value indicates the percent of the variance for that factor that is accounted for by those factors that are directly antecedent to them. This value is derived from the sum of the squares of the path loadings (correlations) for all paths that lead to a given factor.

Figures 2 and 3 depict the proposed causal model and the modified measurement model respectively. In these models observed (or manifest) variables are represented by rectangles and factors (latent variables) are represented by ovals. A straight, single-headed arrow represents a unidirectional causal path, whereas a curved, double-headed arrow represents correlation or covariance between the two variables. Figure 3 includes the specific factor loading values for the observed variables as well as disturbance (error) terms, as well as correlations between factors.

Chapter 3: Results

Of 197 children enrolled in the original study, 6-month follow-up information was available in 166. Of these, 115 (69.8%) were enrolled at the urban site, 30 (18.1%) at the suburban site and 21 (12.7%) at the rural site. See table 1 for the demographic characteristics of the population. Table 2 displays the specific variables that correspond the each latent variable, as well as the criteria used to determine high risk or low risk with each variable. Table 3 displays the frequency distribution for these same variables. Table 4 is the correlation matrix of all the observed variables. The intersection of one variable with another displays the correlation between these two variables. It is of note that, in general, the variables that were grouped together on theoretical grounds have higher correlations with each other.

The initial measurement model did not fit the data well. After modification, however, the fit was good. The structural model improved with modifications as well, resulting in a good fit to the data allowing specific relationships between the latent variables to be determined. See table 4 for the fit indices for the initial and modified measurement model, and initial and modified structural (path analysis) model.

Initial Measurement Model

The initial measurement model, which describes the relationships between the latent variables, was estimated using the maximum likelihood method, which resulted in a chi square value of 134.9 with a $p = 0.0005$ ($df = 85$ $n = 164$, see table 5). The degrees of freedom are calculated by subtracting the total number of parameters in the

model from the number of nonredundent elements. The number of nonredundent elements is determined by multiplying the number of observed variables times the number of observed variables plus 1, all divided by 2. As the chi square value is large (and the p value highly significant) we would normally conclude that the null hypothesis (that the model fits the data) is rejected. However, because the chi square test is known to be excessively sensitive (74), a modified test calculated as a chi square divided by the degrees of freedom was calculated and this was < 2 (1.61) indicating the model may still fit the data. However, the NNFI and the CFI were both < 0.9 (0.86, 0.89 respectively), and the RMSEA was 0.06 indicating an unacceptable level of fit. Therefore the unadjusted (unmodified) measurement model does not fit the data very well.

The specific factor loadings were evaluated next. We first verify that there are no near zero standard errors; all are > 0.01. We then evaluate the t test results. This null hypothesis is rejected for all variables, at a level of $p < 0.05$ meaning that the specific observed variable is significantly associated with the underlying factor. Evaluating the residual covariance matrix revealed that the highest residuals were between variables 10 (receiving asthma education) and 2 (frequency of nocturnal symptoms), between variables 7 (receiving a spacer) and 6 (asthma specialist), and between variables 9 (having a written asthma action plan) and 1 (frequency of daytime symptoms). The large residuals between these variables were negative numbers suggesting that the model overestimated the association observed between these variables.

Dropping these variables from the measurement model would increase the fit of the model to the data. After reviewing all the above information and theory driven decision making employed, it was decided to drop variables 10 (asthma education), 9 (having a written asthma action plan), and 7 (spacer). Even though it may seem that some of these variables would be important to include, it is likely that the remaining variables represent the underlying latent variable adequately without the additional information provided by these dropped variables. For example, in the unadjusted measurement model it was proposed that the latent variable "quality of care indicators" would be represented by variables 5 (inhaled corticosteroids), 6 (having seen an asthma specialist), 7 (having a spacer), 8 (having a peak flow meter), 9 (having a written action plan), and 10 (receiving asthma education). The model fits the data better without variables 7, 9, and 10 being included. Therefore it seems apparent that the latent variable "quality of care indicators" is adequately measured by variables 5 (inhaled steroids), 6 (asthma specialist), and 8 (peak flow meter) alone. At this point there were still two variables associated with high residuals. Variable 2 (nocturnal symptoms) had a high positive residual with variable 1 (daytime symptoms) suggesting that these variables may be measuring the same thing. Variable 2 also had a high negative residual with variable 3 (activity limitation) suggesting that the model overestimates the covariance. Variable 14 (previous hospitalization) had high positive residuals with variables 5 (inhaled steroids) and 13 (previous ED visit), and a high negative residual value with variable 12 (oral or injectable steroids ever). This would suggest that variable 13 (previous ED visits) and variable 14 (previous hospitalizations) might be measuring the same thing. The fact that variable 14 (previous hospitalizations) and

variables 5 (inhaled steroids) had a high positive residual suggests that they are associated to a greater extent than would be explained by the model (which grouped them into different latent variable categories). A high negative residual value between variable 14 (previous hospitalizations) and variable 12 (oral or injectable steroids ever) suggests that the model overestimates the covariance between these two variables. Variables 2 (nocturnal symptoms) and variable 14 (previous hospitalizations) were eliminated. These modifications resulted in high overall goodness of fit indices. This modified model was then used to construct the path analysis. Table 6 includes the individual variable standardized loadings and t values for all variables included in the initial and modified measurement models, (as well as unmodified and modified structural models). All variable loadings are significant (a t value > 1.96 corresponds to $p < 0.05$ and is considered significant) suggesting that the observed variables are significantly associated with the underlying factors. After these modifications were made the fit of the modified model improved, chi square p=0.39, NNFI = 0.99, RMSEA = 0.02, CFI = 0.99 indicating a good level of fit.

Structural Model

The Wald test in the modified measurement model suggested that, based on the data, the covariance pathway between the following factors were not statistically significant and could be eliminated: the path between F3 (current symptom severity) and F1 (six-month morbidity), as well as the path between F4 (previous severe disease) and F3 (current symptom severity) (Figure 2). The results of the path analysis of the structural (causal) model reveal that it has a good fit to the data. The chi square value is

34.41 (df = 32 p = 0.35), the NNFI and CFI are both above 0.9 (0.99 and 0.99 respectively) and the RMSEA = 0.02. (Table 5) These measures suggest a good fit of the model to the data and all individual variable loadings are significant ($t > 1.96$ corresponding to $p < 0.05$). The path from F2 (quality of care indicators) to F1 (six month morbidity) (PF1F2) was nonsignificant with a factor loading of 0.03 and a t value of 0.20, suggesting that the factors do not covary and the path likely does not represent a causal pathway. Thus the path from F2 (quality of care indicators) to F1 (six month morbidity) was eliminated. This modification resulted in the final structural model which revealed a good fit to the data (chi square p=0.40, NNFI = 0.99, RMSEA = 0.02, CFI = 0.99, see table 5). The Paths PF1F4 which represents the impact of previous severe disease (F4) on six month morbidity (F1) (factor loading 0.25, $p < 0.01$), PF2F3 which reflects the impact of current symptom severity (F3) on quality of care (F2) (factor loading 0.52, $p < 0.001$), and PF2F4 which reflects the impact of previous severe disease (F4) on quality of care (F2)

(factor loading 0.62, $p < 0.001$) (see figure 3). The significant factor loadings reveal that the antecedent factors are significantly influencing the subsequent factors. The R^2 values quantify the amount of variance for a factor that is explained by the antecedent factors. The R^2 value for F1 (six month morbidity) and F2 (quality of care) were 0.06 and 0.66 respectively (also displayed in figure 3). This suggests that only 6% of the variance of F1 (six month morbidity) is explained by F4 (previous severe disease) and 66% of the variance of F2 (quality of care) is explained by F3 (current symptom severity) and F4 (previous severe disease).

Chapter 4: Discussion

Causal Model

We have identified relationships between the latent variables as a part of a causal model for asthma morbidity by using path analysis. Significant relationships were identified between previous severe disease and 6 month morbidity, quality of care indicators and current symptoms, and previous severe disease. The association between previous severe disease and future morbidity is a well established risk factor and this relationship was confirmed in our study. Significant associations were noted reflecting the impact of current symptoms and previous severe disease on quality of care. The positive association between current symptoms and quality of care meant that high symptom level was associated with a high level of care. High previous severe disease was also associated with high quality care, however there was no significant relationship between current symptoms and previous severe disease or between quality of care and 6 month morbidity. The relationships between current symptoms or previous severe disease and quality of care could be the result of the fact that patients who were at increased risk for future morbidity were identified and interventions were implemented more often is this group than for lower risk individuals thus increasing the quality of care. It is plausible that once patients were identified as being at increased risk because of previous severe disease, the quality of care improved (thus the statistically significant association). This makes sense clinically as individuals identified as having increased symptoms or previous severe disease would be more apt to be given inhaled steroids or a peak flow meter, or be referred to a specialist. These

clinical interventions that likely occurred in these patients may have decreased their risk of morbidity perhaps explaining the non-significant association between quality of care and six-month morbidity.

Despite increasing knowledge of asthma and advances in treatment options the frequency of healthcare utilization continues to be a problem. This fact is observed clinically and corroborated by the fact that asthma risk models have a low positive predictive value. This study utilizes variables that are standard clinical questions used by healthcare providers in an attempt to gauge the risk of future morbidity, thus the variables are reflective of what is happening clinically even though the construct validity of these observed variables is not established. It is of interest to review the R^2 values for six month morbidity and quality of care. The R^2 value, indicating the percent of variance accounted for by antecedent factors as discussed above, is calculated for any endogenous (dependent) factor (latent variable). Figure 3 displays the path loadings and the p values for each pathway as well as the R^2 value for F1 (6-month morbidity) and F2 (quality of care). The path from previous severe disease to 6 month morbidity (PF1F4) was significant ($P < 0.01$), however, the R^2 value for six month morbidity was only 0.06, suggesting that previous morbidity accounted for only 6% of the variance observed in six month morbidity. Obviously, this suggests that the current model does not provide an adequate explanation of the factors that determine asthma morbidity. This is a reflection of what is occurring clinically. We try to identify high risk individuals and improve the quality of care. Despite these efforts asthma morbidity continues. The fact that the R^2 value for the quality of care latent variable was 0.66, suggested that 66% of the variance in quality of care indicators is accounted for by

current symptom severity and previous severe disease. This is corroborated by the significant path loadings for both factors. It is recognized that various triggers including viral infections, allergens or irritants may precipitate an asthma attack. These unpredictable exposures likely play a role in the lack of stronger path factor loadings for 6 month morbidity. However, it is also possible that other factors such as intrinsic steroid sensitivity, degree of pulmonary deterioration in the presence of a viral infection, perception of airflow obstruction, or other disease specific factors may be operative. It is also possible that 6-month morbidity may be a reflection of social circumstances, learned behaviors, insurance or medical system access which were not addressed in this investigation.

The good news of this study is that we seem to be identifying patients at high risk because of severe symptoms or previous morbidity and increasing their quality of care. The negative conclusion, however, is that we are doing a poor job predicting who is at increased risk for future morbidity. This suggests that we need to better understand the predictors of ED, hospital and urgent care visits by expanding our scope of investigation to include both disease specific factors as well as those that are not disease specific.

Limitations and Implications for the Future

We have demonstrated a methodology of risk stratification modeling utilizing a latent variable approach that includes various dimensions of asthma morbidity risk. The model is valid to the extent that the latent variable groupings are based on established risk factors. The validity of the model would have been improved if the

latent variables had been defined by instruments with established construct validity, rather than being defined according to recognized clinical variables. The latent variable categories of current symptom severity and previous severe disease are likely valid measures of the underlying constructs since they have obvious face validity and are similar to groupings in the literature. The observed variables that defined current symptom severity (i.e., symptom frequency, recent exacerbations, and activity limitations) are similar to those included in several validated measures of current disease control (for example, the ACT). The construct of previous severe disease is relatively uncomplicated being based on prior utilization (hospitalization and/or ED visits), early age of asthma diagnosis (as younger age is associated with increased utilization) (30,35,44) and past oral steroid use. The construct of quality of care indicators is taken directly from national treatment guidelines (2,3). The fact that the model fit better, with some of these commonly accepted clinical variables eliminated (ex. previous hospitalization), suggests that the underlying constructs are more complex than is reflected by current clinical practice. It also suggests that the observed variables exhibit associations with other observed variables and latent factors that go beyond those defined in the model.

The construct of socioeconomic or psychosocial factors is more difficult to define however; previous researchers have included variables related to behavioral, psychological, and social factors. This construct was not adequately represented by the observed variables in the data set; therefore it was not included in the model. In the asthma morbidity risk models reviewed in the background section (33-35,46,49,50,64-69), it is notable that the independent variables included in these models included few

variables that would be considered measures of socioeconomic or psychosocial risk factors. This is surprising given that individual factors have been associated with increased asthma morbidity including factors such as gender (51-53), ethnicity (44,54-56), income or poverty status (31,44,54), educational level (44,54), insurance status (48,57), smoking (58), illicit drug use (59), psychiatric factors (42,60), lack of social support (32), crowding (54) or language barrier (61). The most common factors incorporated into the risk models included age, sex and financial implications of access to healthcare or medications (i.e. insurance type, co-payments for office visits or prescriptions). A few factors reflected the access or assumed continuity of care by determining whether a PCP was listed on a computer database, or whether multiple providers had written prescriptions for the individual. Only two models included educational attainment and household income. These factors may reflect socioeconomic status (SES) that may be playing a role, but they are likely a poor reflection of the role of psychological stress, which is likely contributing to the increased risk associated with poor psychosocial functioning.

These factors likely reflect different constructs and are categorized in various ways in the literature. Socioeconomic or demographic factors are fairly straightforward; however there is more variability in how psychosocial factors are defined. Some authors use the terms 'psychosocial' and 'psychological' interchangeably either explicitly or in practice. To investigate the association between 'psychosocial' factors and the development of symptoms suggestive of asthma, Calam et al (92) defined psychosocial factors as child behavior problems (defined by the Eyberg Child Behavior Inventory), family relationships (defined by the Family

Relationships Index), and parental mental health (defined by the Hospital Anxiety and Depression Scale and the General Health Questionnaire). In a review detailing the childhood asthma disparities of the inner-city poor, Federico and Liu (93), define psychosocial stress as the psychologic stresses of inner-city living including concerns regarding safety and poverty, which may lead to stress-related behaviors in the caregiver. There has been a recent review detailing the health effects of neighborhood violence on urban asthma control (94). In another review focusing on asthma in urban children Eggleston (95) includes stress related to poverty as well as specific psychological functioning and potential drinking problems under the category of psychosocial stress. In a study to determine whether psychosocial factors and health behaviors were important in asthma deaths (96), 533 cases and 533 controls were evaluated in regard to various measures of behavioral, psychological, and social factors. The social factors evaluated included sexual problems, bereavement, marital breakdown or family problems, domestic abuse, isolation, housing, financial, or employment problems, drug or alcohol abuse, or criminal record. These social factors likely have significant psychiatric implications however; they were distinguished from more formal psychiatric diagnoses, use of psychiatric medications, or mental healthcare utilization.

More extensive hypothesized frameworks for psychosocial factors have been utilized by Adams et al (97) and proposed by Wade et al (98). In a study to evaluate whether better asthma management (as defined by the use of a written asthma action plan and increased inhaled steroid usage) prevented asthma related ED visits or hospitalizations, Adams et al incorporated individual characteristics such as coping

styles and attitudes toward asthma management into the evaluation. They defined psychosocial factors as including personal coping styles (avoidance coping, active coping, and denial), attitudes and behaviors regarding asthma medication (including self-reported adherence), as well as preferences regarding decision making autonomy (asthma autonomy preference index), level of confidence (self-efficacy) in managing asthma, indicators of perceived emotional social support and participation. During the 12 month follow up, those who had an asthma related hospital admission were more apt to use avoidance coping and have lower autonomy preferences in moderate attacks, as well as have more severe disease, have previous hospitalizations as well as no written action plan. Individuals who had two or more ED visits for asthma were found to have a greater dislike of asthma medications, as well as increased severity of disease, regular use of oral steroids, previous hospitalization, and no written action plan. Barton et al (99) have suggested that coping, as opposed to a component of psychosocial functioning should be viewed as a mediator of the psychosocial impediments of asthma control.

The most extensive proposed model defining psychosocial characteristics was proposed by Wade et al. The most proximal factors included aspects of the asthma management. This included caretaker's attitudes and beliefs, knowledge, problem solving and responsibility for tasks. Less proximate to asthma management, the model included three adjustment factors including caretaker adjustment (screening for alcoholism and psychological symptoms), family adjustment (evaluating the family environment and parenting practices), and child adjustment (including behavior problems, cognitive competence, and self-competence). The most distal elements of

the model incorporated a measure of stressful life events and degree of social support. This model is based on the asthma literature; however, it has not been validated yet.

In addition to measures of current symptom severity, previous disease severity, and quality of care, it is clear that incorporating measures of socioeconomic and psychosocial functioning will be important to more accurately include the entire context of disease. Chen et al recently demonstrated an association between SES, psychological stress, and immune pathways that play a role in asthma (100). It is clear that psychosocial factors are much more complex and extensive than is reflected in previous risk models or by the observed variables that were present in the data set used in this investigation. It is likely that exploratory techniques are the best current approach to clarify this construct because of the variable nature of socioeconomic and psychosocial risk factors and the lack of clarity as to what factors are most operative in increasing morbidity risk in asthmatic patients. Based on the results of the study by Adams et al it seems reasonable to not only include suggestions for self-monitoring including a written action plan, but also asking about areas of concern (dislike) regarding asthma medications, as well as confidence issues in managing attacks.

The current model is likely an oversimplification of the reality of clinical medicine, however as it is a reflection of what is occurring in clinics it likely suggests that our approach to asthma care is an oversimplification and does not account for all the operative elements. Our treatments will not be specifically directed at the area of need for the individual patient until we are able to develop a risk model that moves beyond simple associations to a multi-dimensional causal model, thus identifying the

needed intervention for a given patient. The current study is a first step in this direction.

Further efforts to augment this model and identify limitations will likely include further clarification of the underlying factors (constructs) that impact asthma morbidity. This is reflected by the fact that the R^2 for 6 month morbidity was so low. The current model clearly did not identify the factors that were playing a role in 6 month morbidity. This could be because the observed variables were a poor reflection of the underlying construct or it could be a reflection that the hypothesized factors are really not the most significant factors causing asthma morbidity. The answer to this question has tremendous clinical application. If the lack of associations with 6 month morbidity were because of poor construct validity of the model, then the solution would be to utilize reliable and validated measures of these underlying constructs leaving the model relatively unchanged, however, if the lack of associations reflects the impact of, as of yet unidentified factors, then this suggests that our current clinical approach needs to be reassessed in addition to this model. We have also not begun to explore the influence of mediators and moderators, which are not included in the model. Future directions could include utilizing reliable and valid instruments to measure the underlying constructs as well as reassessing the model itself. These issues should be pursued prior to the application of these methods to other asthmatic populations. However, in the future applying these methods to other populations will be important as the same factors and factor relationships may be different in other asthmatic populations.

In summary, quality of care is high in response to high current symptoms or previous severe disease. Six month morbidity was related to previous severe disease,

albeit only modestly. The lack of other associations could be the result of low model sensitivity, lack of construct validity of the observed variables, or the impact of yet unidentified latent variables. The fact that the latent variables were represented by single clinical questions and not instruments with established construct validity, though a limitation from a research standpoint, likely increased the reflection of what is actually occurring in clinics. Therefore these results might be as much a critique of clinical practice patterns as the inadequacy of the current model. This is consistent with the fact that current clinical risk models for asthma morbidity have low positive predictive values, as outlined in the background section. Further research is needed to define the characteristics and impact of SES and psychosocial functioning on asthma risk. Only with these factors better defined and included in future models will the predictive accuracy improve.

APPENDIX A: TABLES AND FIGURES

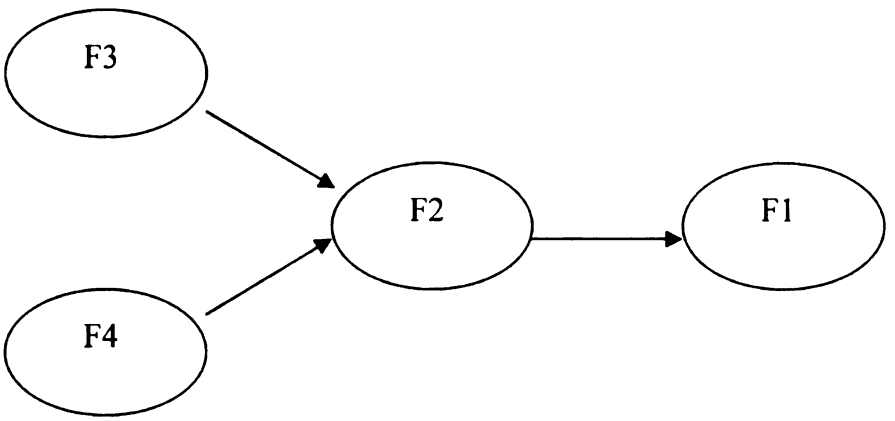

Figure 1: Proposed causal model. The following factors (latent variables) are represented by ovals; F1: 6 month morbidity, F2: quality of care indicators, F3: current symptom severity, F4: previous severe disease. A straight, single-headed arrow represents a unidirectional causal path.

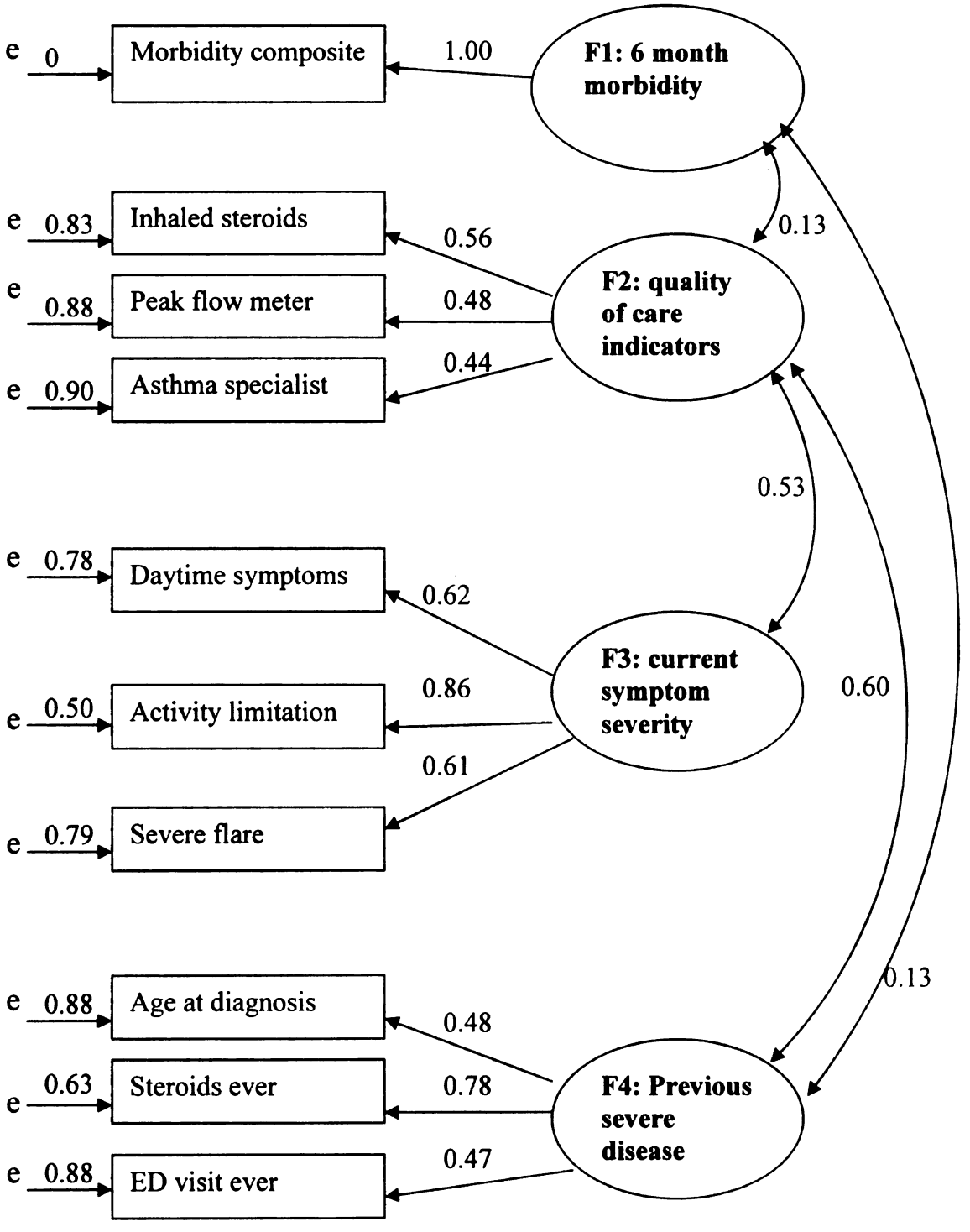

Figure 2: Confirmatory Factor Analysis: modified measurement model. Observed (or manifest) variables are represented by rectangles and factors (latent variables) are represented by ovals. A straight, single-headed arrow represents a unidirectional causal path, whereas a curved, double-headed arrow represents correlation or covariance between the two variables.

Table 1: Demographic Characteristics

	Variable	% (n)
Age	Mean age 8.1 years	Range 1 – 17years
Hospital location	Urban	69.3 (115)
	Suburban	18.1 (30)
	Rural	12.7 (21)
Gender	Female	38.6 (64)
	Male	61.5 (102)
Race (survey instructions: "select one or more")	Caucasion/white	71.7 (119)
	African American	30.1 (50)
	Hispanic	15.7 (26)
	American Indian or Alaska Native	4.2 (7)
	Asian	1.2 (2)
	other	1.2 (2)
Parental education level	Less than high school	13.9 (23)
	High school or GED	31.3 (52)
	1-3 years of college	33.1 (55)
	4 years of college or more	21.1 (35)

Table 2: Latent Variable Definitions

Latent Variable	Observed Variable Abbreviation (and #)	Source (survey form and question #)	Definition	Low risk criteria	High risk criteria
6 month morbidity (F1)	SMUC (15)	SMF* 2, 7	urgent care – 6 month f/u	3 level composite outcome 1) no urgent care 2) urgent care (no ED/hosp) 3) ED or hospitalization	
	SMED (15)		ED – 6 month f/u		
	SMH (15)		Hosp – 6 month f/u		
Quality of care (F2)	ICS (5)	CVF* 17	Inhaled corticosteroid	Present on med sheet	Absent on med sheet
	AS (6)	CVF* 13	Asthma specialist	Previously seen an asthma specialist	No asthma specialist previously seen
	SP (7)	CVF* 21	have a spacer	Previously received a spacer	No spacer previously received
	PFMTR (8)	CVF* 22	have a peak flow meter	Previously received a peak flow meter	No peak flow meter previously received
	WAP (9)	CVF* 23	written action plan	Previously received a written action plan	No written action plan previously received
	ASTHED (10)	CVF* 24	asthma education	Previously received asthma education	No asthma education previously received

*The four survey instruments: clinical data form (CDF), child cohort visit form (CVF), two week follow-up form (TWF), and six month follow-up form (SMF).

Table 2 (continued): Latent Variable Definitions

Latent Variable	Observed Variable	Source	Definition	Low risk criteria	High risk criteria
Current symptoms (F3)	FDS (1)	CVF* 7	Frequency of daytime symptoms	≤2x/wk	≥3x/wk
	FNS (2)	CVF* 8	Frequency of nocturnal symptoms	≤2x/4wk	≥3x/4wk
	FAL (3)	CVF* 9	Frequency of activity limitation	≤2x/last 4 weeks	≥3x/last 4 weeks
	SF (4)	CVF* 10	Severe flare and frequency	No severe flare in previous 4 weeks	Severe flare in previous 4 weeks
	AD (11)	CVF* 6a	Age at diagnosis	> 5 years of age	< 5 years of age
Prior morbidity (F4)	SE (12)	CVF* 18	Oral or injectable steroids ever	No previous oral/injectable steroids ever	Previous oral or injectable steroids
	EDE (13)	CVF* 26	previous ED visit ever	No previous ED visits ever	The presence of a previous ED visit
	HE (14)	CVF* 25	Previous hospitalization ever	No previous hospitalizations ever	The presence of a previous hospitalizations

*The four survey instruments: clinical data form (CDF), child cohort visit form (CVF), two week follow-up form (TWF), and six month follow-up form (SMF).

Table 3: Variable Description and Frequency Distribution

Latent Variable	Observed Variable Abbreviation (and #)	Low risk % (n)	High risk % (n)
6 month morbidity (F1)	SMUC (15)	3 level composite outcome 1) no urgent care 78.3 (130) 2) urgent care (no ED/hosp) 13.9 (23) 3) ED or hospitalization 7.8 (13)	
	SMED (15)		
	SMH (15)		
Quality of care (F2)	ICS (5)	Y 52.4 (87)	N 47.6 (79)
	AS (6)	Y 27.7 (46)	N 72.3 (120)
	SP (7)	Y 65.7 (109)	N 34.3 (57)
	PFMTR (8)	Y 43.4 (72)	N 56.6 (94)
	WAP (9)	Y 45.8 (76)	N 54.2 (90)
	ASTHED (10)	Y 71.1 (118)	N 28.9 (48)
Current symptoms (F3)	FDS (1)	≤2x/wk 74.1 (123)	≥3x/wk 25.9 (43)
	FNS (2)	≤2x/4wk 74.1 (123)	≥3x/4wk 25.9 (43)
	FAL (3)	≤2x/last 4 weeks 75.9 (126)	≥3x/last 4 weeks 24.1 (40)
	SF (4)	N 82.5 (137)	Y 17.5 (29)
Prior morbidity (F4)	AD (11)	> 5 years 31.3 (52)	< 5 years 68.7 (114)
	SE (12)	N 22.3 (36)	Y 77.7 (129)
	EDE (13)	N 16.3 (27)	Y 83.7 (139)
	HE (14)	N 48.8 (81)	Y 51.2 (85)

Table 4: Correlation Matrix

	FDS	FNS	FAL	SF	ICS	AS	SP	PFMTR	WAP	ASTHED	AD	SE	EDE	HE	SMM
FDS	1.00														
FNS	0.50	1.00													
FAL	0.54	0.41	1.00												
SF	0.42	0.34	0.52	1.00											
ICS	0.16	0.23	0.28	0.25	1.00										
AS	0.13	0.09	0.22	0.12	0.30	1.00									
SP	0.17	0.14	-.04	-.00	0.13	-.00	1.00								
PFMTR	0.18	0.18	0.25	0.08	0.22	0.24	0.30	1.00							
WAP	-.03	0.07	0.10	0.07	0.33	0.31	0.18	0.37	1.00						
ASTHED	-.02	-.08	0.02	0.08	0.26	0.19	0.27	0.26	0.42	1.00					
AD	0.13	0.07	-.05	-.07	0.09	0.11	0.28	0.20	0.14	0.11	1.00				
SE	0.08	0.08	0.09	0.13	0.33	0.17	0.30	0.29	0.20	0.28	0.37	1.00			
EDE	0.07	-.00	-.06	-.01	0.11	0.03	0.27	0.19	0.10	0.26	0.27	0.36	1.00		
HE	0.08	0.06	0.07	0.10	0.33	0.04	0.21	0.17	0.21	0.18	0.28	0.31	0.39	1.00	
SMM	-.08	0.01	0.01	0.01	0.12	0.14	-.00	0.06	0.01	0.16	0.12	0.16	0.13	0.14	1.00

Table 5: Measurement Model and Structural Model Fit Indices

	Initial Measurement Model	Modified Measurement Model	Structural (path analysis) Model unmodified	Structural (path analysis) Model modified
Chi square	134.91	33.66	34.41	34.45
Chi square df	85	32	32	33
Prob > chi square	0.0005	0.39	0.35	0.40
Non-normed Index (Bentler/Bonett)	0.86	0.99	0.99	0.99
RMSEA	0.06	0.02	0.02	0.02
Comparative Fit Index (Bentler)	0.89	0.99	0.99	0.99

Table 6: Initial and Modified Measurement and Structural Models: Individual Variable Standardized Loadings and t Values

	Initial Measurement Model		Modified Measurement Model		Structural (path analysis) Model unmodified		Structural (path analysis) Model modified	
Variable	Standardized loading	t value	Standardized loading	t value	Standardized loading	t value	Standardized loading	t value
V1 = FDS	0.72	9.25	0.62	7.67	0.62	6.25	0.62	6.26
V2 = FNS	0.59	7.38						
V3 = FAL	0.76	9.75	0.86	10.48	0.87		0.87	
V4 = SF	0.63	7.85	0.61	7.49	0.61	6.18	0.61	6.18
V5 = ICS	0.54	6.25	0.56	5.93	0.56		0.56	
V6 = AS	0.40	4.58	0.44	4.66	0.43	3.73	0.43	3.72
V7 = SP	0.40	4.56						
V8 = PFMTR	0.57	6.68	0.48	5.14	0.49	4.04	0.49	4.05
V9 = WAP	0.60	7.12						
V10 = ASTHED	0.55	6.39						
V11 = AD	0.50	5.70	0.48	5.25	0.49	4.17	0.49	4.19
V12 = SE	0.67	7.80	0.78	7.54	0.76		0.76	
V13 = EDE	0.56	6.40	0.47	5.13	0.48	4.13	0.48	4.14
V14 = HE	0.55	6.36						
V15 = Composite 6 month outcome	1.00		1.00		1.00		1.00	

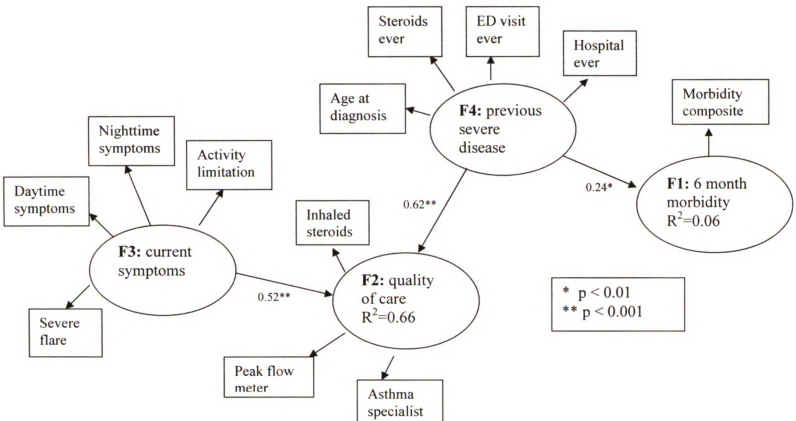

Figure 3: Path Analysis Model. Observed (or manifest) variables are represented by rectangles and factors (latent variables) are represented by ovals. A straight, single-headed arrow represents a unidirectional causal path, whereas a curved, double-headed arrow represents correlation or covariance between the two variables.

APPENDIX B: SURVEY INTRUMENTS

CHILD COHORT VISIT FORM

Emergency Department (CIRCLE ONE):

Gerber **Blodgett** **Butterworth**

ED visit date (mm/dd/yr) __ / __ / __

ED triage time (hh:mm) ___ / ___

Insurance Company _____

Presenting complaint -

_____

PLEASE ANSWER EVERY QUESTION. IF PARENT DOES NOT KNOW AN ANSWER PLEASE WRITE IN 'DK' (DON'T KNOW). RECORD ONLY ONE ANSWER TO EACH QUESTION UNLESS SPECIFICALLY INSTRUCTED TO 'CHECK ALL THAT APPLY'.

A. DEMOGRAPHIC INFORMATION

1. Date of child's birth (mm/dd/yr) __ / __ / __

2. Sex: ..... Male 01
..... Female 02

3. Is your child Spanish, Hispanic or Latino?

No.....01
Yes 02

4. What race is your child? (SELECT ONE OR MORE)

White or Caucasian.....01
Black or African-American.....02
Asian 03
American Indian or Alaska Native 04
Native Hawaiian or Pacific Islander 05
Other race, please specify: _____ 06

5. How much schooling have **you** (parent or guardian) completed?
Less than high school.....01
Graduated high school or got GED.....02
1-3 years of college.....03
4-year college degree or more.....04

B. ASTHMA HISTORY

6. Has a doctor **ever** told you that your child has asthma?

No.....01
Yes.....02

If Yes, 6a. How old was your child when a doctor first diagnosed him/her with asthma?

< 2 years old.....01
2 - 5 years.....02
5 - 9 years.....03
10 - 14 years.....04
15 - 18 years.....05

The following questions are about your child's asthma symptoms over the last 4 weeks that is from _____ to _____ (but do not refer to this current episode)

7. How often in the last 4 weeks has your child had asthma symptoms **during the day**? (i.e., wheezing, a dry cough, shortness of breath, and/or chest tightness)

Never.....01
Less than once a week.....02
1 or 2 times a week.....03
3 to 6 times a week.....04
Every day.....05
Continually (all the time).....06

8. How many times over the last 4 weeks did your child **wake up at night** because of asthma symptoms? (i.e., wheezing, a dry cough, shortness of breath, and/or chest tightness)

Never.....01
1 or 2 times.....02
3 to 4 times.....03
5 to 9 times.....04
10 or more times.....05

9. How many times over the last 4 weeks has your child's activities been **affected or restricted** by his/her asthma symptoms?

Never.....01
1 or 2 times.....02
3 to 4 times.....03
5 or more times.....04
All the time.....05

10. In the last 4 weeks has your child's asthma symptoms ever been severe enough to limit your child's speech to **only 1 or 2 words** at a time between breaths?

No.....01
Yes.....02

If Yes, 10a. How many times has this occurred in the last 4 weeks? _____

C. USUAL SOURCE OF ASTHMA CARE

11. Does your child have a "primary care provider" or other regular source of medical care (such as a family doctor, pediatric nurse practitioner or medical clinic)?

No (IF NO, SKIP TO QUESTION 13).....01
Yes 02

12. Does this doctor/provider/clinic take primary responsibility for your child's regular **asthma care**? (i.e., directs your child's asthma care and writes most of your prescriptions) [= REGULAR ASTHMA CARE PROVIDER]

No.....01
Yes (IF YES, SKIP TO QUESTION 14).....02

13. What type of doctor/provider/clinic takes primary responsibility for your regular **asthma care**? (i.e., directs your child's asthma care and writes most of your prescriptions) [= REGULAR ASTHMA CARE PROVIDER]

Emergency Department (specify: _____).....01
Med center (= urgent care center) (specify: _____).....02
An asthma specialist (specify pulmonologist, allergist,
or asthma clinic _____).....03
Other provider/site (specify: _____).....04
No regular asthma care provider (SKIP TO QUESTION 16).....05

14. How many times in the last 12 months did your child visit this (doctor/provider/clinic) for a regularly scheduled appointment for asthma care?
[SCHEDULED APPT. = REGULAR OR ROUTINE VISIT TO DISCUSS ASTHMA]

_____ times or Never

15. How many months ago was the last regularly scheduled appointment for asthma care with this doctor/provider/clinic?

≤ 1 month ago 01
1 – 3 months ago.....02
4 - 6 months ago.....03
7 – 12 months ago.....04
> 12 months ago.....05

16. In the last 12 months, has your child visited an <u>asthma specialist</u> (e.g., pulmonologist, allergist, asthma clinic or other specialist)? (LEAVE BLANK IF SPECIALIST IS REGULAR ASTHMA CARE PROVIDER AS DEFINED IN QUESTION 13).

No..01
Yes 02

D. CURRENT ASTHMA TREATMENT, MANAGEMENT AND CONTROL

17. RECORD ALL PRESCRIPTION AND NON-PRESCRIPTION ASTHMA RELATED MEDICATIONS USED IN THE LAST 4 WEEKS IN THE FOLLOWING TABLE (EXCEPT SYSTEMIC STEROIDS – SEE QUESTION 18)

Medicatio (name)	Frequency Doctor Rx'd	Current Frequency of Use	Route	Has Rx Run Out?	Used in last four weeks?
	Daily QOD weekly PRN	Daily QOD Weekly PRN	PO Inh Neb	Yes No	Yes No
	Daily QOD weekly PRN	Daily QOD Weekly PRN	PO Inh Neb	Yes No	Yes No
	Daily QOD weekly PRN	Daily QOD Weekly PRN	PO Inh Neb	Yes No	Yes No
	Daily QOD weekly PRN	Daily QOD Weekly PRN	PO Inh Neb	Yes No	Yes No
	Daily QOD weekly PRN	Daily QOD Weekly PRN	PO Inh Neb	Yes No	Yes No
	Daily QOD weekly PRN	Daily QOD Weekly PRN	PO Inh Neb	Yes No	Yes No
	Daily QOD weekly PRN	Daily QOD Weekly PRN	PO Inh Neb	Yes No	Yes No

18. Has your child ***ever*** taken steroids orally or by injection for a severe asthma attack?

No..01
Yes 02

If Yes, 18a. **Over the past 4 weeks**, has child taken any steroids orally or by injection for asthma? (CHECK ORAL AND INJECTION IF HAVE TAKEN BOTH)

No.....01
Yes – Injection.....02
Yes – Oral.....03

If Yes - Oral,

18b. How many days in the past 4 weeks did child take oral steroids? _____ days

18c. How many days ago did child last take oral steroids? _____ days

IF CHILD NOT CURRENTLY USING INHALED CORTICOSTEROIDS:

19. Has child ever used an inhaled steroid for asthma?

No.....01
Yes.....02

If Yes,

19a. Names (s) _____

19b. For how long did child take an inhaled steroid for asthma?

_____ weeks / months / years.

19c. When did child last use an inhaled steroid for asthma?

_____ months / years ago.

20. Are you usually able to get your asthma prescriptions filled?
No.....01
Yes.....02

If No, 20a. Why not? Specify main reason _____

21. A spacer is a device that you put between the mouth and inhaler to make it easier to breathe medicine into the lungs. Does your child have a spacer?
No.....01
Yes.....02

If Yes, 21a. How often does child use the spacer when using the inhaler?
Never.....01
Rarely.....02
Occasionally.....03
Usually.....04
Always.....05

22. A peak flow meter measures how hard you can blow air out of the lungs. Does your child have a peak flow meter?

No.....01
Yes.....02

If Yes, 22a. On average, how often does your child use the peak flow meter?

Rarely.....01
< 1/week.....02
1-3/week.....03
4-6/week.....04
Daily.....05
Only during exacerbations.....06

23.Has a doctor or a nurse ever given you a written plan for you to treat your child's asthma? [= ASTHMA ACTION PLAN]

No.....01
Yes.....02

24. Have you or your child ever received education about asthma control and treatment from a health professional?

No.....01
Yes.....02

If Yes, 24a. What did you learn about (CIRCLE YES OR NO FOR EACH ITEM):

Things that can trigger your asthma?	YES	NO
Medications and treatments?	YES	NO
How to use an inhaler or nebulizer?	YES	NO
How to use a peak flow meter?	YES	NO
What to do during an asthma attack?	YES	NO
How to use a written action plan?	YES	NO

E. EMERGENCY ASTHMA CARE

[THE FOLLOWING ANSWERS SHOULD NOT INCLUDE THE CURRENT EPISODE]

25. Has your child **ever** been hospitalized overnight for treatment of asthma symptoms [i.e., wheezing, dry cough, shortness of breath, and/or chest tightness]?

No.....01
Yes.....02

If Yes, 25a. How many times in the last 12 months, did your child stay over night in the hospital for treatment of asthma symptoms? ..... _____ times

26. Excluding today, has your child ever previously gone to an emergency room for urgent treatment of asthma symptoms?

No.....01
Yes.....02

If Yes, 26a. How many times in the last 12 months, did your child visit an emergency room for urgent treatment of asthma symptoms?

_____ times

26b. Which emergency rooms did your child visit?

_____

26c. How long ago was the last visit? _____ days / weeks / months ago

27. When your child is having problems with asthma symptoms that requires **urgent** treatment - that is, treatment needed within 24 hours of recognizing a problem, where do you usually end up taking him/her?

Regular asthma care provider (as defined previously)
SKIP TO QUESTION 28.....01
Emergency Department (if after hours or RACP is NA).....02
..... (specify: _____)
Emergency department (ALL times) specify: _____) .03
Med care center (specify: _____) 04
An asthma specialist (specify pulmonologist, allergist,
or asthma clinic: _____).....05
Other provider/site (specify: _____).....06
No specific location/provider.....07

If answer is NOT regular asthma care provider then:

27a. Why do you use this particular place for asthma care? (CHECK ALL THAT APPLY)

No regular asthma care provider.....01
Regular asthma care provider not available.....02
Insurance company dictates.....03
No insurance.....04
Other cost issues (specify: _____).....05
Transport issues (specify: _____).....06
Convenience.....07
Best medical care.....08
Past experience/comfort with people/place.....09
Other (specify: _____).....10

28. How many times in the last 12 months did your child visit a doctor's office or clinic for urgent treatment of asthma symptoms? [URGENT VISIT = NOT SCHEDULED OR SCHEDULED < 24 HRS AHEAD OF TIME. DO NOT INCLUDE ED OR HOSPITAL VISITS] _____ times or Never

F. ASTHMA AWARENESS OF PARENT

Please tell us if the following statements are true of false.

29. Most people with asthma can become free of symptoms with proper treatment
    True 01
    False 02

30. Asthma is characterized by inflammation of the airways, which if controlled can greatly reduce symptoms
    True 01
    False 02

31. If someone with asthma feels well, it is okay to stop taking his or her medications?
    True 01
    False 02

Parent Name_____

That's it! Do you have any questions or comments? As you know, we're going to call you in 2 weeks to see how [*child*] is doing.

What's the best number to reach you? ☐ Home(_____) _ _ _- _ _ _ _
☐ Work (____)- _ _ _- _ _ _ _

Other (specify) (___ ___ ___) ___ ___ ___ – ___ ___ ___ ___

When is the best time to call: Between _____ and _____ AM PM

Is it okay to leave a message on the answering machine? YES NO

If you are not available when we call, is there another family member who we could talk to that is familiar enough with [child's] asthma care?

_____ (name)

_____ (relationship)

6-MONTH CHILD COHORT FOLLOW-UP FORM

LAST VISIT REVIEW		
Emergency Department (check one)	o 1. GERBER o 2. BLODGETT o 3. BUTTERWORTH	
ED Visit Date (mm/dd) |___|___| / |___|___|		
Subsequent relapse ED/Hosp visits?	o 0. No	o 1. Yes (specify date (mm/dd)|___|___| / |___|___|
		o 2. Yes (specify date (mm/dd)|___|___| / |___|___|
		o 3. Yes (specify date (mm/dd)|___|___| / |___|___|
Date 2-wk FU call completed (mm/dd) |___|___| / |___|___|		Who was interviewed? Name and Relationship?

CALLING LOG

Date	Time	Caller initials	Comment
____/__	____:____	____	
____/__	____:____	____	
____/__	____:__	____	

INTERVIEW STATUS

o 1. Agreed to participate	o 2. refused f/u interview	o 3. unreachable x 8 (over at least 10 days)	o 4. Other (specify)

CALLING SCRIPT

Phone I: _____

Phone II: _____

Hello. May I speak with _____ ? My name is ____

and I work for the MSU/Grand Rapids Asthma Project.

On _____ (date) you took _____ [*child*] to the _____

(hospital) emergency dept for an asthma attack.

We are calling to learn how [*child*] has been doing over the last 6 months.

Is this a good time to talk for 5 minutes?

NO: When would be a better time to contact you?

_____

YES: Great. Please remember that all of your answers will be kept confidential, and will be used for asthma research only.

1. Date Interview Completed? (mm/dd) |__|__| / |__|__|
2. Who was interviewed? o 1. Mother o 2. Father o 3. Grandparent o 4. Other (specify):

2a. Name _____

SECTION A: EMERGENCY ASTHMA VISITS

FIRST CONFIRM INFORMATION COLLECTED AT 2-WEEK FU CALL

Your [child] was first enrolled in this study when he/she visited _____ ED on __/__/____. We conducted our first follow-up call with you about X weeks later on __/__/____. At this call we determined that since leaving the ED/Hospital the [child] had:

- visited the ED or Urgent Care center for an asthma problem on ___ occasions,
- and- had been hospitalized overnight on ___ occasions. OK?

During this first call we also confirmed that the doctor/provider/clinic that takes primary responsibility for your child's asthma was _____. Is this **still** correct?

Now we would like to ask you about your child's asthma experience **since the time we last talked to you on** __/__/____ and today. OK?

1. Is the above information correct?
   No (What data is incorrect?: _____01 .....RACPTrue
   Yes 02 .....RACPTrue

2. Since we last talked to you on |__|__| / |__|__| , has he/she had a worsening of his/her asthma that led you to take him/her for *urgent* medical treatment?
   No 01..... ⇒ **SKIP TO 8**
   Yes 02 .....UV

3. How many times has this happened since we last talked to you?
   (times) |___|___|.....UVCnt

4. Thinking about the first time this happened since we last talked to you. When did you take [*child*] for urgent medical treatment for his/her asthma?
   (mm/dd) |___|___| / |___|___|..... UVDate

5. Where did you first take [*child*] for this urgent asthma visit?

Regular asthma care provider (as defined above) 01 ..... ⇒ **SKIP TO 6**
Hospital ED (specify:_____02..... UVWhen2
Med care center (specify: _____03..... UVWhen3
An asthma specialist: pulmonologist 04
An asthma specialist: allergist 05
An asthma specialist: asthma clinic 06
Other provider/site (specify:_____07 ..... UVWhen7
No specific location/provider 08..... UVWhen

5a. Why did you use this particular place for asthma care?
(CHECK ALL THAT APPLY)

No regular asthma care provider.....01
Regular asthma care provider not available.....02
Insurance company dictates 03
No insurance 04
Other cost issues (specify: _____05 ... UVPlace5
Transport issues (specify: _____06 .. UVPLace6
Convenience.....07
Best medical care 08
Past experience/comfort with people/place 09
Other (specify: _____10 ... UVPlace10
Severity of episode – EMERGENCY! 11 ..... UVPlace

6. At this visit did the doctor change [*child*]'s asthma medicines or make any other changes in the management of his/her asthma? (PROMPT – FOR EXAMPLE, GIVE YOU A NEW MEDICATION, OR CHANGE THE WAY YOU USE YOUR EXISITING MEDICATIONS, OR CHANGE THE WAY YOU MONITOR OR MANAGE YOUR ASTHMA)

No asthma treatment given (including no inhaled ß-agonist).....01
Given inhaled ß-agonist treatment but no new asthma Rx 02
Change in treatment plan (specify below) ..... 03 ChngRx

Details_____

_____ChnRxTxt

7. Did this visit result in child being transferred to an emergency department or hospital?

No 01..... Trans2
Yes (Specify ED: _____02 ..... Trans

If Yes, 7a. Was [*child*] then admitted to the hospital overnight?

No.....01
Yes (Specify hospital: _____02..... TransNit

IF Q3 = MORE THAN ONE "RELAPSE" VISIT — REPEAT QUESTIONS FOR SECOND VISIT SINCE 2-WEEK FU CALL COMPLETED. AT END OF THIS SECTION CONFIRM SINCE 2-WEEK FU CALL:

Total (cumulative) number of ED/Urgent Care visits |___|___| ..... EDUCCnt

Total (cumulative) number of overnight hospitalizations |___|___| ..... NightCnt

SECTION B: ROUTINE ASTHMA VISITS

FIRST CONFIRM INFORMATION COLLECTED AT 2-WEEK FU CALL (SPECIFICALLY Q.8A)

At the time that we first contacted you on __/__, we determined that since leaving the hospital/ED that the child HAD / HAD NOT seen the child's regular asthma care provider
(RACP) for a **follow-up** asthma check-up. OK?

IF CHILD HAD NOT YET SEEN RACP AT 2-WEEK FU CALL FOR FOLLOW-UP VISIT

8. When did [*child*] first see this doctor/nurse/clinic *(RACP)* for a **follow-up** asthma check-up?

(mm/dd) |___|___| / |___|___| ..... ChkDate
or number of days after ED visit (days) |___|___|___| ..... ChkDays

Now again we would like to ask you about your child's experience **since the time we last talked to you on** __/__.

8a. Since we last talked to you, has the child seen his/her regular asthma care provider *(RACP)* for a **routine** asthma check up?

No 01 ..... ⇒ **SKIP TO 9**
Yes 02 ..... RACPApt

8b. How many **routine** asthma check-ups has child had with this doctor/nurse/ clinic (*RACP*) since we last talked to you?

(number of checkups) |___|___| ..... ChkCnt

8c. As a result of this visit (these visits), did the doctor change [*child*]'s asthma medicines or make any other changes in the management of his/her asthma? (PROMPT –

NEW MEDS?, OR CHANGE EXISITING MEDS?, OR CHANGE IN MANAGEMENT OF ASTHMA?)

No.....01
Yes 02 ..... NewRx

Describe: _____

_____NewRxTxt

9. Has child had <u>any other</u> doctor visits specifically related to his/her asthma care and treatment since we last talked to you on __ / __ ? (i.e., NOT WITH RACP, e.g., ASTHMA SPECIALISTS)

No.....01 ⇒ **SKIP TO 10**
Yes .....02 .ODV

9a. When did [*child*] <u>first</u> see ANOTHER doctor/nurse/clinic (*NOT RACP)* for an <u>asthma related visit</u>?

(mm/dd) |___|___| / |___|___|..... ODVDate
or number of days after ED visit (days) |___|___|___|.....ODVDays

NOT APPLICABLE (first visit recorded at 2-WK FU call) 99

9b. How many <u>asthma related visits</u> has child had with ANOTHER doctor/nurse/clinic (*NOT RACP*) since we last talked to you?

(number of visits) |___|___| ..... ARVCnt

9c. Where did the visit take place and who was it with? (CHECK MORE THAN ONE RESPONSE IF VISITS TO MORE THAN ONE SPECIALIST)

Asthma specialist (specify type: _____01 .....ARVLoc1

Specialty Asthma Clinic 02

Other primary care type doctor/clinic.....03

Other (specify: _____04 .....ARVLoc2
ARVLoc

Name & location _____ARVLocNL

9d. What was the primary purpose of this (these) visit(s)?

Describe: _____

_____ARVWhy

9e. As a result of this (these) visit(s), did the doctor change [*child*]'s asthma medicines or make any other changes in the management of his/her asthma? (PROMPT –

NEW MEDS?, OR CHANGE EXISITING MEDS?, OR CHANGE IN MANAGEMENT OF ASTHMA?)

No..01

Yes 02 .... ARVNewRx

Describe: ____

______________________________________ARVNTxt

10. Has child had any other doctor visits for health problems <u>not related to asthma</u> since we last talked to you on __/__? (# visits) |___|___| .... NonARV

If Yes,

10a. What was visit for? ________________________NonARVTx

C. CURRENT ASTHMA RELATED MEDICATIONS

11. RECORD ALL PRESCRIPTION AND NON-PRESCRIPTION ASTHMA RELATED MEDICATIONS USED IN THE LAST 6 MONTHS IN THE FOLLOWING TABLE (EXCEPT SYSTEMIC STEROIDS – SEE QUESTION 11a)

Medication (name)	Frequency Doctor Rx'd	Current Frequency of Use	Route	Time period of use (months) (→ *most recent*)
	Daily QOD weekly PRN	Daily QOD Week PRN	PO Inh Neb	1 2 3 4 5 6
	Daily QOD weekly PRN	Daily QOD Week PRN	PO Inh Neb	1 2 3 4 5 6
	Daily QOD weekly PRN	Daily QOD Week PRN	PO Inh Neb	1 2 3 4 5 6
	Daily QOD weekly PRN	Daily QOD Week PRN	PO Inh Neb	1 2 3 4 5 6
	Daily QOD weekly PRN	Daily QOD Week PRN	PO Inh Neb	1 2 3 4 5 6
	Daily QOD weekly PRN	Daily QOD Week PRN	PO Inh Neb	1 2 3 4 5 6
	Daily QOD weekly PRN	Daily QOD Week PRN	PO Inh Neb	1 2 3 4 5 6

COMMENTS: ____

11a. **Over the past 6 months**, has child taken any steroids orally or by injection for asthma? (CHECK ORAL AND INJECTION IF HAVE TAKEN BOTH)

No.....01
Yes – Injection.....02
Yes – Oral.....03

If Yes - Oral,

11b. How many rounds of oral steroids has child taken over the last 6 months?
_____ rounds

11c. How long ago was the last round of oral steroids? _____ days / weeks ago

D. CURRENT SYMPTOMS, CONTROL AND QUALITY OF LIFE

12. How often in the last 4 weeks has your child had asthma symptoms during the day? (i.e., wheezing, a dry cough, shortness of breath, and/or chest tightness)

Never.....01
Less than once a week.....02
1 or 2 times a week.....03
3 to 6 times a week.....04
Every day.....05
Continually (all the time).....06..SympDay

13. How many times over the last 4 weeks did your child wake up at night because of asthma symptoms? (i.e., wheezing, a dry cough, shortness of breath, and/or chest tightness)

Never.....01
1 or 2 times.....02
3 to 4 times.....03
5 to 9 times.....04
10 or more times.....05 . SympNit

14. How many times over the last 4 weeks has your child's activities been affected or restricted by his/her asthma symptoms?

Never.....01
1 or 2 times.....02
3 to 4 times.....03
5 or more times.....04
All the time.....05 Restrict

15. Over the past 4 weeks has your child's asthma symptoms been severe enough to limit your child's speech to only 1 or 2 words at a time between breaths?

No.....01
Yes.....02 Speech

If Yes,

15a. How many times has this occurred in the last 4 weeks? |___|___|SpeecCnt

16. Over the past 4 weeks how many days has your child had to use his/her quick relief medicine. (i.e., short acting bronchodilator or rescue medicine)

(days) |___|___| .....QuicDays

17. Over the past 4 weeks, how much discomfort or distress has [*child*] felt because of asthma symptoms? Would you say...

None.....01
Mild.....02
Moderate 03
Severe 04.Distress

18. How would you rate [*child*]'s asthma condition now compared to around the time period when he/she went to the emergency department on __ / __?

Much worse.....01
A little worse.....02
About the same 03
A little better 04
Much better .....05 CondNow

IF CHILD IS 7 YEARS OF AGE OR OLDER:

19. Over the past 4 weeks how often did your child use his/her peak flow meter?

None .....01⇒ **SKIP TO 20**
< 1/week.....02
1-3/week.....03
4-6/week.....04
Daily.....05
Only during exacerbations 06
Doesn't have a PFM .....07 ⇒ **SKIP TO 20**
PeakFreq

19a. What is the child's personal best peak flow reading? (liters/minute)
|___|___|___|

19b. Over the past 4 weeks, what were the highest and lowest peak flow readings?

Highest reading (liters/minute) |___|___|___| .....PeakHigh

Lowest reading (liters/minute) |___|___|___| ..... PeakLow

19c. Over the past 4 weeks, has the peak flow dropped below 80% of [child's] personnel best?

No 01
Yes .....02 PeakDrop

If Yes,

19d. What did you do when this occurred?

Details: _____ PkDropDo

ALL AGES:

20. A spacer is a device that you put between the mouth and inhaler to make it easier to breathe medicine into the lungs. Does your child have a spacer?

No.....01
Yes.....02

If Yes,

20a. Over the past 4 weeks, how often has your child used the spacer when using the inhaler?

Never.....01
Rarely.....02
Occasionally.....03
Usually.....04
Always.....05

21. Have you and your child received **asthma education since** your initial ED visit?

No.....01
Yes.....02

If Yes

21a. What was the source of this education? – that is, who provided it?

Your regular asthma care provider.....01
Asthma specialist (allergist, or pulmonologist).....02
ED or Urgent Care Center.....03
Asthma Coalition.....04
Other health professional (Specify _____).....05
[SPECIFY TYPE OF PROFESSIONAL AND ORGANIZATION
e.g., RN-SCHOOL, RN-COMMUNTY)

21b. What did you learn about? (Circle Yes or No for each item)

Things that can trigger your asthma?	YES	NO
Medications and treatments?	YES	NO
How to use an inhaler or nebulizer?	YES	NO
How to use a peak flow meter?	YES	NO
What to do during an asthma attack?	YES	NO
How to use a written action plan?	YES	NO

22. Did you have **an asthma management plan** at the time of the initial ED visit?

No.....01
Yes.....02

If No,

22a. Do you have an **asthma management plan** now?

No.....01
Yes.....02

23. How **confident** do you feel about your ability to:

23a. Manage your child's asthma on a day-to-day basis?
(READ and CIRCLE ONE)

Very unsure	Somewhat unsure	Somewhat confident	Very confident	Don't know
1	2	3	4	5

23b. Manage or control an asthma attack or exacerbation?
(READ and CIRCLE ONE)

Very unsure	Somewhat unsure	Somewhat confident	Very confident	Don't know
1	2	3	4	5

24. If your child had an asthma attack today, how likely are you to do the following?

24a. Measure the asthma severity using a PFM (READ and CIRCLE ONE)

Definitely Yes	Probably Yes	Probably Not	Definitely NOT	Don't Know	N/A (< 7 yrs)
1	2	3	4	5	6

24b. Increase the amount of rescue medication (albuterol) (either dose or freq) (READ and CIRCLE ONE)

Definitely Yes	Probably Yes	Probably Not	Definitely NOT	Don't know
1	2	3	4	5

24c. Wait to see if the symptoms subside after using the medication before calling your doctor or going to the ED (READ and CIRCLE ONE)

Definitely Yes	Probably Yes	Probably Not	Definitely NOT	Don't know
1	2	3	4	5

25. If the symptoms continued to persist what action would you take next?

Call PCP.....01
Go directly to ED/Urgent Care - always.....02
Go directly to ED/Urgent Care - if after hours and PCP N/A 03
Continue with treatment.....04
Not sure.....05
Other (Specify) _____.....05

26. What other actions or steps do you think would help you better control and manage your child's asthma?

That's it! Do you have any questions or comments? [pause] This is the last time we need to call you. Thank you for your help with this asthma study.

COMMENTS: Comments

```
libname cohort "F:\";
data test;
 set cohort.PedsFudeleted;
IF AgeDg in (01,02)
  then AD = 02;
IF AgeDg = > 03
   then AD = 01;
IF SympDay in (01,02,03)
   then FDS = 01;
IF SympDay in (04,05,06)
   then FDS = 02;
IF SympDay = 999
   then FDS = .;
IF SympNgt in (01,02)
   then FNS = 01;
IF SympNgt in (03,04,05)
   then FNS = 02;
IF SympNgt = 999
   then FNS = .;
IF ActRstr in (01,02)
    then FAL = 01;
IF ActRstr in (03,04,05)
    then FAL = 02;
IF ActRstr = 999
   then FAL = .;
IF AAttack = 01
    then SF = 01;
IF AAttack = 02
    then SF = 02;
IF AAttack = 999
    then SF = .;
IF CDF64 = 01
    THEN ICS = 02;
IF CDF64 = 02
    THEN ICS = 01;
IF CDF64 = 999
    THEN ICS = 01;
IF AsthSpec = 01
   then AS = 01;
IF AsthSpec = 02
   then AS = 02;
IF AsthSpec = 999
   then AS = 01;
IF Spacer = 01
```

```
  then SP = 01;
IF Spacer = 02
  then SP = 02;
IF Spacer = 999
  then SP = .;
IF PFM = 01
  then PFMTR = 01;
IF PFM = 02
  then PFMTR = 02;
IF PFM = 999
  then PFMTR = .;
IF ActPlan = 01
  then WAP = 01;
IF ActPlan = 02
  then WAP = 02;
IF ActPlan = 999
  then WAP = .;
IF AsthEdu = 01
  then ASTHED = 01;
IF AsthEdu = 02
  then ASTHED = 02;
IF AsthEdu = 999
  then ASTHED = .;
IF WhereGo in (3,4)
  then US = 02;
 else US = 01;
IF EverSOI = 01
 then SE = 01;
IF EverSOI = 02
 then SE = 02;
IF EverSOI = 999
  then SE = .;
IF EverEr = 01
  then EDE = 01;
IF EverEr = 02
  then EDE = 02;
IF EverEr = 999
  then EDE = .;
IF EverHosp = 01
  then HE = 01;
IF EverHosp = 02
  then HE = 02;
IF EverHosp = 999
  then HE = .;
IF EDE = 01
  then PM = 01;
```

IF (EDE = **02** and HE = **01**)
  then PM = **02**;
IF HE = **02**
  then PM = **03**;
IF PCP = **1**
  then PCP_TM = **02**;
IF PCP = **2**
  then PCP_TM = **01**;
IF PCP = **999**
  then PCP_TM = **.**;
IF (Hispanic = **02** or Race02 = **1** or Race04 = **1**)
  then RaceRsk = **02**;
else RaceRsk = **01**;
IF Educate in (**01**,**02**)
  then PEL = **02**;
IF Educate in (**03**,**04**)
  then PEL = **01**;
IF Educate = **999**
  then PEL = **.**;
IF Prescrpt = **01**
  then FP = **02**;
IF Prescrpt = **02**
  then FP = **01**;
IF Prescrpt = **999**
  then FP = **.**;
IF RACPApt_2 = **01**
  then FUA = **02**;
IF RACPApt_2 = **02**
  then FUA = **01**;
IF RACPApt_2 = **999**
  then FUA = **01**;
IF C2 = **01**
  then SMUC = **01**;
IF C2 = **02**
  then SMUC = **02**;
IF C2 = **999**
  then SMUC = **01**;
IF C7 = **01**
  then SMED = **01**;
IF C7 = **02**
  then SMED = **02**;
IF C7 = **999**
  then SMED = **01**;
IF C7a = **01**
  then SMH = **01**;
IF C7a = **02**

```
  then SMH = 02;
IF C7a = 999
  then SMH = 01;
IF SMUC in (01,999)
  then SMM = 01;
IF (SMUC = 02 and SMED = 01)
  then SMM = 02;
IF (SMED = 02 or SMH = 02)
  then SMM = 03;
run;

PROC CORR DATA=TEST;
TITLE 'CORRELATION MATRIX';
VAR FDS FNS FAL SF ICS AS SP PFMTR WAP ASTHED AD SE EDE HE SMM;
RUN;
```

CORRELATION MATRIX 09:40 Tuesday, March 6, 2007 237

The CORR Procedure

15 Variables: FDS FNS FAL SF ICS AS SP PFMTR WAP ASTHED AD SE EDE HE SMM

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
FDS	166	1.25904	0.43943	209.00000	1.00000	2.00000
FNS	166	1.25904	0.43943	209.00000	1.00000	2.00000
FAL	166	1.24096	0.42896	206.00000	1.00000	2.00000
SF	166	1.17470	0.38086	195.00000	1.00000	2.00000
ICS	165	1.52727	0.50078	252.00000	1.00000	2.00000
AS	166	1.17470	0.38086	195.00000	1.00000	2.00000
SP	166	1.65663	0.47627	275.00000	1.00000	2.00000
PFMTR	166	1.43373	0.49709	238.00000	1.00000	2.00000
WAP	164	1.46341	0.50019	240.00000	1.00000	2.00000
ASTHED	166	1.71084	0.45474	284.00000	1.00000	2.00000
AD	166	1.68675	0.46522	280.00000	1.00000	2.00000
SE	165	1.78182	0.41427	294.00000	1.00000	2.00000
EDE	166	1.83735	0.37016	305.00000	1.00000	2.00000
HE	166	1.51205	0.50137	251.00000	1.00000	2.00000
SMM	166	1.29518	0.60571	215.00000	1.00000	3.00000

Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	FDS	FNS	FAL	SF	ICS	AS	SP	PFMTR
FDS	1.00000	0.49783	0.53496	0.41601	0.16315	0.12631	0.16695	0.17617
		<.0001	<.0001	<.0001	0.0363	0.1049	0.0316	0.0232
	166	166	166	166	165	166	166	166
FNS	0.49783	1.00000	0.40635	0.34359	0.23029	0.09010	0.13799	0.17617
	<.0001		<.0001	<.0001	0.0029	0.2483	0.0762	0.0232
	166	166	166	166	165	166	166	166
FAL	0.53496	0.40635	1.00000	0.51980	0.28069	0.22303	-0.03753	0.24587
	<.0001	<.0001		<.0001	0.0003	0.0039	0.6312	0.0014
	166	166	166	166	165	166	166	166
SF	0.41601	0.34359	0.51980	1.00000	0.24587	0.12258	-0.00141	0.07752
	<.0001	<.0001	<.0001		0.0015	0.1156	0.9856	0.3208
	166	166	166	166	165	166	166	166
ICS	0.16315	0.23029	0.28069	0.24587	1.00000	0.29870	0.12904	0.22119
	0.0363	0.0029	0.0003	0.0015		<.0001	0.0986	0.0043
	165	165	165	165	165	165	165	165
AS	0.12631	0.09010	0.22303	0.12258	0.29870	1.00000	-0.00141	0.23759
	0.1049	0.2483	0.0039	0.1156	<.0001		0.9856	0.0021
	166	166	166	166	165	166	166	166
SP	0.16695	0.13799	-0.03753	-0.00141	0.12904	-0.00141	1.00000	0.30010
	0.0316	0.0762	0.6312	0.9856	0.0986	0.9856		<.0001
	166	166	166	166	165	166	166	166
PFMTR	0.17617	0.17617	0.24587	0.07752	0.22119	0.23759	0.30010	1.00000
	0.0232	0.0232	0.0014	0.3208	0.0043	0.0021	<.0001	
	166	166	166	166	165	166	166	166

WAP	-0.02824	0.07106	0.09825	0.06579	0.32910	0.30643	0.17925	0.37259
	0.7196	0.3659	0.2107	0.4026	<.0001	<.0001	0.0216	<.0001
	164	164	164	164	163	164	164	164
ASTHED	-0.01717	-0.07783	0.01759	0.08348	0.26309	0.18846	0.26635	0.26327
	0.8262	0.3189	0.8220	0.2849	0.0006	0.0150	0.0005	0.0006
	166	166	166	166	165	166	166	166
AD	0.13251	0.07322	-0.04464	-0.06553	0.08932	0.10550	0.27748	0.19798
	0.0888	0.3485	0.5679	0.4016	0.2539	0.1761	0.0003	0.0106
	166	166	166	166	165	166	166	166
SE	0.07962	0.07962	0.09339	0.12828	0.32757	0.16683	0.29513	0.28728
	0.3093	0.3093	0.2328	0.1006	<.0001	0.0322	0.0001	0.0002
	165	165	165	165	164	165	165	165
EDE	0.07429	-0.00022	-0.05702	-0.01217	0.10620	0.03082	0.26570	0.18810
	0.3415	0.9977	0.4656	0.8763	0.1746	0.6935	0.0005	0.0152
	166	166	166	166	165	166	166	166
HE	0.08203	0.05452	0.07096	0.10000	0.33289	0.03652	0.20779	0.17345
	0.2934	0.4854	0.3636	0.1999	<.0001	0.6404	0.0072	0.0254
	166	166	166	166	165	166	166	166
SMM	-0.08408	0.00700	0.00450	0.01155	0.12362	0.14291	-0.00367	0.05529
	0.2815	0.9287	0.9542	0.8826	0.1137	0.0662	0.9626	0.4792
	166	166	166	166	165	166	166	166

The CORR Procedure

Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	WAP	ASTHED	AD	SE	EDE	HE	SMM
FDS	-0.02824	-0.01717	0.13251	0.07962	0.07429	0.08203	-0.08408
	0.7196	0.8262	0.0888	0.3093	0.3415	0.2934	0.2815
	164	166	166	165	166	166	166
FNS	0.07106	-0.07783	0.07322	0.07962	-0.00022	0.05452	0.00700
	0.3659	0.3189	0.3485	0.3093	0.9977	0.4854	0.9287
	164	166	166	165	166	166	166
FAL	0.09825	0.01759	-0.04464	0.09339	-0.05702	0.07096	0.00450
	0.2107	0.8220	0.5679	0.2328	0.4656	0.3636	0.9542
	164	166	166	165	166	166	166
SF	0.06579	0.08348	-0.06553	0.12828	-0.01217	0.10000	0.01155
	0.4026	0.2849	0.4016	0.1006	0.8763	0.1999	0.8826
	164	166	166	165	166	166	166
ICS	0.32910	0.26309	0.08932	0.32757	0.10620	0.33289	0.12362
	<.0001	0.0006	0.2539	<.0001	0.1746	<.0001	0.1137
	163	165	165	164	165	165	165
AS	0.30643	0.18846	0.10550	0.16683	0.03082	0.03652	0.14291
	<.0001	0.0150	0.1761	0.0322	0.6935	0.6404	0.0662
	164	166	166	165	166	166	166
SP	0.17925	0.26635	0.27748	0.29513	0.26570	0.20779	-0.00367
	0.0216	0.0005	0.0003	0.0001	0.0005	0.0072	0.9626
	164	166	166	165	166	166	166
PFMTR	0.37259	0.26327	0.19798	0.28728	0.18810	0.17345	0.05529
	<.0001	0.0006	0.0106	0.0002	0.0152	0.0254	0.4792
	164	166	166	165	166	166	166
WAP	1.00000	0.41692	0.13734	0.20116	0.10207	0.21070	0.00590
		<.0001	0.0795	0.0100	0.1934	0.0068	0.9402

	164	164	164	163	164	164	164
ASTHED	0.41692	1.00000	0.11356	0.27551	0.25897	0.17487	0.15773
	<.0001		0.1452	0.0003	0.0008	0.0242	0.0424
	164	166	166	165	166	166	166
AD	0.13734	0.11356	1.00000	0.36812	0.26544	0.27612	0.11505
	0.0795	0.1452		<.0001	0.0005	0.0003	0.1399
	164	166	166	165	166	166	166
SE	0.20116	0.27551	0.36812	1.00000	0.36132	0.30963	0.15746
	0.0100	0.0003	<.0001		<.0001	<.0001	0.0434
	163	165	165	165	165	165	165
EDE	0.10207	0.25897	0.26544	0.36132	1.00000	0.38617	0.13434
	0.1934	0.0008	0.0005	<.0001		<.0001	0.0844
	164	166	166	165	166	166	166
HE	0.21070	0.17487	0.27612	0.30963	0.38617	1.00000	0.13790
	0.0068	0.0242	0.0003	<.0001	<.0001		0.0764
	164	166	166	165	166	166	166
SMM	0.00590	0.15773	0.11505	0.15746	0.13434	0.13790	1.00000
	0.9402	0.0424	0.1399	0.0434	0.0844	0.0764	
	164	166	166	165	166	166	166

```
DATA PATH (type=corr);
INPUT _TYPE_ $ _NAME_ $ V1-V15;
DATALINES;
N . 166 166 166 166 165 166 166 166 164 166 166 165 166 166 166
STD . 0.43943 0.43943 0.42896 0.38086 0.50078 0.38086 0.47627 0.49709 0.50019
0.45474 0.46522 0.41427 0.37016 0.50137 0.60571
CORR V1 1.00000 . . . . . .
CORR V2 0.49783 1.00000 . . . . . .
CORR V3 0.53496 0.40635 1.00000 . . . . . .
CORR V4 0.41601 0.34359 0.51980 1.00000 . . . . . .
CORR V5 0.16315 0.23029 0.28069 0.24587 1.00000 . . . . . .
CORR V6 0.12631 0.09010 0.22303 0.12258 0.29870 1.00000 . . . . . .
CORR V7 0.16695 0.13799 -0.03753 -0.00141 0.12904 -0.00141 1.00000 . . . . . .
CORR V8 0.17617 0.17617 0.24587 0.07752 0.22119 0.23759 0.30010 1.00000 . . . . . .
CORR V9 -0.02824 0.07106 0.09825 0.06579 0.32910 0.30643 0.17925 0.37259
1.00000 . . . . . .
CORR V10 -0.01717 -0.07783 0.01759 0.08348 0.26309 0.18846 0.26635 0.26327
0.41692 1.00000 . . . . .
CORR V11 0.13251 0.07322 -0.04464 -0.06553 0.08932 0.10550 0.27748 0.19798
0.13734 0.11356 1.00000 . . . .
CORR V12 0.07962 0.07962 0.09339 0.12828 0.32757 0.16683 0.29513 0.28728
0.20116 0.27551 0.36812 1.00000 . . .
CORR V13 0.07429 -0.00022 -0.05702 -0.01217 0.10620 0.03082 0.26570 0.18810
0.10207 0.25897 0.26544 0.36132 1.00000 . .
CORR V14 0.08203 0.05452 0.07096 0.10000 0.33289 0.03652 0.20779 0.17345
0.21070 0.17487 0.27612 0.30963 0.38617 1.00000 .
CORR V15 -0.08408 0.00700 0.00450 0.01155 0.12362 0.14291 -0.00367 0.05529
0.00590 0.15773 0.11505 0.15746 0.13434 0.13790 1.00000
;
PROC CALIS COVARIANCE CORR RESIDUAL MODIFICATION;
LINEQS
V1  =  LV1F3 F3 + E1,
V2  =  LV2F3 F3 + E2,
V3  =  LV3F3 F3 + E3,
V4  =  LV4F3 F3 + E4,
V5  =  LV5F2 F2 + E5,
V6  =  LV6F2 F2 + E6,
V7  =  LV7F2 F2 + E7,
V8  =  LV8F2 F2 + E8,
V9  =  LV9F2 F2 + E9,
V10 = LV10F2 F2 + E10,
V11 = LV11F4 F4 + E11,
V12 = LV12F4 F4 + E12,
V13 = LV13F4 F4 + E13,
V14 = LV14F4 F4 + E14,
V15 = F1 + E15;
```

```
STD
F1 = 1,
F2 = 1,
F3 = 1,
F4 = 1,
E1-E15 = VARE1-VARE15;
COV
F1 F2 = CF1F2,
F1 F3 = CF1F3,
F1 F4 = CF1F4,
F2 F3 = CF2F3,
F2 F4 = CF2F4,
F3 F4 = CF3F4;
VAR V1-V15;
RUN;
```

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The CALIS Procedure
Covariance Structure Analysis: Pattern and Initial Values

LINEQS Model Statement

	Matrix	Rows	Columns	------Matrix Type-------	
Term 1	1 _SEL_	15	34	SELECTION	
	2 _BETA_	34	34	EQSBETA	IMINUSINV
	3 _GAMMA_	34	19	EQSGAMMA	
	4 _PHI_	19	19	SYMMETRIC	

The 15 Endogenous Variables

Manifest V1 V2 V3 V4 V5 V6 V7 V8 V9 V10 V11
V12 V13 V14 V15
Latent

The 19 Exogenous Variables

Manifest
Latent F3 F2 F4 F1
Error E1 E2 E3 E4 E5 E6 E7 E8 E9 E10 E11
E12 E13 E14 E15

Manifest Variable Equations with Initial Estimates

V1	=	.*F3	+ 1.0000 E1	
		LV1F3		
V2	=	.*F3	+ 1.0000 E2	
		LV2F3		
V3	=	.*F3	+ 1.0000 E3	
		LV3F3		
V4	=	.*F3	+ 1.0000 E4	
		LV4F3		
V5	=	.*F2	+ 1.0000 E5	
		LV5F2		
V6	=	.*F2	+ 1.0000 E6	
		LV6F2		
V7	=	.*F2	+ 1.0000 E7	
		LV7F2		
V8	=	.*F2	+ 1.0000 E8	
		LV8F2		
V9	=	.*F2	+ 1.0000 E9	
		LV9F2		
V10	=	.*F2	+ 1.0000 E10	
		LV10F2		
V11	=	.*F4	+ 1.0000 E11	
		LV11F4		
V12	=	.*F4	+ 1.0000 E12	
		LV12F4		
V13	=	.*F4	+ 1.0000 E13	
		LV13F4		
V14	=	.*F4	+ 1.0000 E14	
		LV14F4		
V15	=	1.0000 F1	+ 1.0000 E15	

Variances of Exogenous Variables

Variable	Parameter	Estimate
F3		1.00000
F2		1.00000
F4		1.00000
F1		1.00000
E1	VARE1	.
E2	VARE2	.
E3	VARE3	.
E4	VARE4	.
E5	VARE5	.
E6	VARE6	.
E7	VARE7	.
E8	VARE8	.
E9	VARE9	.
E10	VARE10	.
E11	VARE11	.
E12	VARE12	.
E13	VARE13	.
E14	VARE14	.
E15	VARE15	.

Covariances Among Exogenous Variables

Var1	Var2	Parameter	Estimate
F3	F2	CF2F3	.
F3	F4	CF3F4	.
F2	F4	CF2F4	.
F3	F1	CF1F3	.
F2	F1	CF1F2	.
F4	F1	CF1F4	.

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The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Observations	164	Model Terms	1
Variables	15	Model Matrices	4
Informations	120	Parameters	35

Variable	Mean	Std Dev
V1	0	0.43943
V2	0	0.43943
V3	0	0.42896
V4	0	0.38086
V5	0	0.50078
V6	0	0.38086
V7	0	0.47627
V8	0	0.49709
V9	0	0.50019
V10	0	0.45474
V11	0	0.46522
V12	0	0.41427
V13	0	0.37016
V14	0	0.50137
V15	0	0.60571

Covariances

	V1	V2	V3	V4	V5
V1	0.1930987249	0.0961303382	0.1008388327	0.0696239785	0.0359024228
V2	0.0961303382	0.1930987249	0.0765961187	0.0575036724	0.0506771005
V3	0.1008388327	0.0765961187	0.1840066816	0.0849216522	0.0602963069
V4	0.0696239785	0.0575036724	0.0849216522	0.1450543396	0.0468940649
V5	0.0359024228	0.0506771005	0.0602963069	0.0468940649	0.2507806084
V6	0.0211394070	0.0150792540	0.0364372376	0.0177807609	0.0569701760
V7	0.0349405191	0.0288795581	-.0076674082	-.0002557630	0.0307768775

V8	0.0384819157	0.0384819157	0.0524272846	0.0146762180
0.0550614306				
V9	-.0062071094	0.0156188808	0.0210806676	0.0125331505
0.0824346623				
V10	-.0034310193	-.0155524886	0.0034311981	0.0144580912
0.0599120906				
V11	0.0270892346	0.0149684836	-.0089083928	-.0116108472
0.0208091369				
V12	0.0144942371	0.0144942371	0.0165958942	0.0202398737
0.0679570598				
V13	0.0120839675	-.0000357851	-.0090538542	-.0017157161
0.0196861586				
V14	0.0180726051	0.0120116839	0.0152612022	0.0190951778
0.0835807125				
V15	-.0223793336	0.0018631700	0.0011692141	0.0026644777
0.0374973398				

Covariances

	V6	V7	V8	V9	V10
V1	0.0211394070	0.0349405191	0.0384819157	-.0062071094	-
.0034310193					
V2	0.0150792540	0.0288795581	0.0384819157	0.0156188808	-
.0155524886					
V3	0.0364372376	-.0076674082	0.0524272846	0.0210806676	
0.0034311981					
V4	0.0177807609	-.0002557630	0.0146762180	0.0125331505	
0.0144580912					
V5	0.0569701760	0.0307768775	0.0550614306	0.0824346623	
0.0599120906					
V6	0.1450543396	-.0002557630	0.0449809421	0.0583756392	
0.0326398164					
V7	-.0002557630	0.2268331129	0.0710483912	0.0427019193	
0.0576858219					
V8	0.0449809421	0.0710483912	0.2470984681	0.0926405716	
0.0595113164					
V9	0.0583756392	0.0427019193	0.0926405716	0.2501900361	
0.0948311225					
V10	0.0326398164	0.0576858219	0.0595113164	0.0948311225	
0.2067884676					
V11	0.0186928792	0.0614813350	0.0457841044	0.0319587971	
0.0240240885					
V12	0.0263222492	0.0582304396	0.0591594194	0.0416831102	
0.0519019899					

V13 0.0043449770 0.0468418746 0.0346109332 0.0188982942
0.0435915288
V14 0.0069735589 0.0496176525 0.0432282520 0.0528394008
0.0398691348
V15 0.0329680095 -.0010587271 0.0166473979 0.0017875235
0.0434452404

Covariances

	V11	V12	V13	V14	V15
V1	0.0270892346	0.0144942371	0.0120839675	0.0180726051	-.0223793336
V2	0.0149684836	0.0144942371	-.0000357851	0.0120116839	0.0018631700
V3	-.0089083928	0.0165958942	-.0090538542	0.0152612022	0.0011692141
V4	-.0116108472	0.0202398737	-.0017157161	0.0190951778	0.0026644777
V5	0.0208091369	0.0679570598	0.0196861586	0.0835807125	0.0374973398
V6	0.0186928792	0.0263222492	0.0043449770	0.0069735589	0.0329680095
V7	0.0614813350	0.0582304396	0.0468418746	0.0496176525	-.0010587271
V8	0.0457841044	0.0591594194	0.0346109332	0.0432282520	0.0166473979
V9	0.0319587971	0.0416831102	0.0188982942	0.0528394008	0.0017875235
V10	0.0240240885	0.0519019899	0.0435915288	0.0398691348	0.0434452404
V11	0.2164296484	0.0709465489	0.0457103169	0.0644042587	0.0324197561
V12	0.0709465489	0.1716196329	0.0554070429	0.0643109405	0.0395110413
V13	0.0457103169	0.0554070429	0.1370184256	0.0716681778	0.0301203195
V14	0.0644042587	0.0643109405	0.0716681778	0.2513718769	0.0418781371
V15	0.0324197561	0.0395110413	0.0301203195	0.0418781371	0.3668846041

Determinant 1.74698E-12 Ln -27.073133

NOTE: Some initial estimates computed by instrumental variable method.

Vector of Initial Estimates

	Parameter	Estimate	Type
1	LV1F3	0.37713	Matrix Entry: _GAMMA_[1:1]
2	LV2F3	0.29026	Matrix Entry: _GAMMA_[2:1]
3	LV3F3	0.35410	Matrix Entry: _GAMMA_[3:1]
4	LV4F3	0.27046	Matrix Entry: _GAMMA_[4:1]
5	LV5F2	0.43113	Matrix Entry: _GAMMA_[5:2]
6	LV6F2	0.16263	Matrix Entry: _GAMMA_[6:2]
7	LV7F2	0.20893	Matrix Entry: _GAMMA_[7:2]
8	LV8F2	0.33922	Matrix Entry: _GAMMA_[8:2]
9	LV9F2	0.30125	Matrix Entry: _GAMMA_[9:2]
10	LV10F2	0.20595	Matrix Entry: _GAMMA_[10:2]
11	LV11F4	0.30554	Matrix Entry: _GAMMA_[11:3]
12	LV12F4	0.36084	Matrix Entry: _GAMMA_[12:3]
13	LV13F4	0.25400	Matrix Entry: _GAMMA_[13:3]
14	LV14F4	0.30337	Matrix Entry: _GAMMA_[14:3]
15	CF2F3	0.26043	Matrix Entry: _PHI_[2:1]
16	CF3F4	0.10316	Matrix Entry: _PHI_[3:1]
17	CF2F4	0.45210	Matrix Entry: _PHI_[3:2]
18	CF1F3	-0.02628	Matrix Entry: _PHI_[4:1]
19	CF1F2	0.11932	Matrix Entry: _PHI_[4:2]
20	CF1F4	0.19336	Matrix Entry: _PHI_[4:3]
21	VARE1	0.05087	Matrix Entry: _PHI_[5:5]
22	VARE2	0.10885	Matrix Entry: _PHI_[6:6]
23	VARE3	0.05862	Matrix Entry: _PHI_[7:7]
24	VARE4	0.07190	Matrix Entry: _PHI_[8:8]
25	VARE5	0.06490	Matrix Entry: _PHI_[9:9]
26	VARE6	0.11861	Matrix Entry: _PHI_[10:10]
27	VARE7	0.18318	Matrix Entry: _PHI_[11:11]
28	VARE8	0.13202	Matrix Entry: _PHI_[12:12]
29	VARE9	0.15944	Matrix Entry: _PHI_[13:13]
30	VARE10	0.16437	Matrix Entry: _PHI_[14:14]
31	VARE11	0.12307	Matrix Entry: _PHI_[15:15]
32	VARE12	0.04141	Matrix Entry: _PHI_[16:16]
33	VARE13	0.07250	Matrix Entry: _PHI_[17:17]
34	VARE14	0.15934	Matrix Entry: _PHI_[18:18]
35	VARE15	0.15546	Matrix Entry: _PHI_[19:19]

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Levenberg-Marquardt Optimization

Scaling Update of More (1978)

Parameter Estimates	35
Functions (Observations)	120

Optimization Start

Active Constraints	0	Objective Function	2.1923056363
Max Abs Gradient Element	8.3496409147	Radius	179.97629786

Iter	Restarts	Function Calls	Active Constraints	Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change
1	0	2	0	0.85709	1.3352	0.6541	0	0.847
2	0	3	0	0.82946	0.0276	0.0862	0	0.928
3	0	4	0	0.82789	0.00157	0.0353	0	0.746
4	0	5	0	0.82771	0.000188	0.0119	0	0.693
5	0	6	0	0.82768	0.000026	0.00537	0	0.675
6	0	7	0	0.82768	3.693E-6	0.00179	0	0.663
7	0	8	0	0.82768	5.434E-7	0.000792	0	0.659
8	0	9	0	0.82768	8.076E-8	0.000268	0	0.656
9	0	10	0	0.82768	1.21E-8	0.000117	0	0.655
10	0	11	0	0.82768	1.821E-9	0.000040	0	0.656

Optimization Results

Iterations	10	Function Calls	12
Jacobian Calls	11	Active Constraints	0
Objective Function	0.8276760975	Max Abs Gradient Element	0.000040333
Lambda	0	Actual Over Pred Change	0.655586944
Radius	0.0003017209		

GCONV convergence criterion satisfied.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Predicted Model Matrix

	V1	V2	V3	V4	V5
V1	0.1930987249	0.0827791594	0.1027940973	0.0756139626	0.0259725872
V2	0.0827791594	0.1930987249	0.0846892491	0.0622962785	0.0213981052
V3	0.1027940973	0.0846892491	0.1840066816	0.0773587188	0.0265718923
V4	0.0756139626	0.0622962785	0.0773587188	0.1450543396	0.0195459284
V5	0.0259725872	0.0213981052	0.0265718923	0.0195459284	0.2507806085
V6	0.0148880317	0.0122658427	0.0152315659	0.0112041361	0.0411075376
V7	0.0185273832	0.0152642050	0.0189548937	0.0139429662	0.0511561983
V8	0.0273550847	0.0225371071	0.0279862902	0.0205863406	0.0755304796
V9	0.0291086937	0.0239818577	0.0297803630	0.0219060365	0.0803723923
V10	0.0240596000	0.0198220473	0.0246147638	0.0181062909	0.0664312741
V11	0.0099708004	0.0082146701	0.0102008718	0.0075036248	0.0406534788
V12	0.0119064538	0.0098094021	0.0121811896	0.0089603201	0.0485456283
V13	0.0088289979	0.0072739703	0.0090327229	0.0066443501	0.0359980611
V14	0.0118931385	0.0097984319	0.0121675670	0.0089502995	0.0484913382
V15	-.0053271258	-.0043888734	-.0054500467	-.0040089814	0.0241002562

Predicted Model Matrix

	V6	V7	V8	V9	V10
V1	0.0148880317	0.0185273832	0.0273550847	0.0291086937	0.0240596000

V2	0.0122658427	0.0152642050	0.0225371071	0.0239818577
0.0198220473				
V3	0.0152315659	0.0189548937	0.0279862902	0.0297803630
0.0246147638				
V4	0.0112041361	0.0139429662	0.0205863406	0.0219060365
0.0181062909				
V5	0.0411075376	0.0511561983	0.0755304796	0.0803723923
0.0664312741				
V6	0.1450543396	0.0293238057	0.0432956549	0.0460711408
0.0380797995				
V7	0.0293238057	0.2268331129	0.0538791967	0.0573331450
0.0473883352				
V8	0.0432956549	0.0538791967	0.2470984682	0.0846505424
0.0699673510				
V9	0.0460711408	0.0573331450	0.0846505424	0.2501900362
0.0744526371				
V10	0.0380797995	0.0473883352	0.0699673510	0.0744526371
0.2067884676				
V11	0.0233034266	0.0289999057	0.0428174269	0.0455622558
0.0376591839				
V12	0.0278273722	0.0346297213	0.0511296684	0.0544073570
0.0449700443				
V13	0.0206348435	0.0256789924	0.0379142054	0.0403447113
0.0333466567				
V14	0.0277962520	0.0345909938	0.0510724885	0.0543465116
0.0449197529				
V15	0.0138147723	0.0171917675	0.0253830912	0.0270102848
0.0223251738				

Predicted Model Matrix

	V11	V12	V13	V14	V15
V1	0.0099708004	0.0119064538	0.0088289979	0.0118931385	-
.0053271258					
V2	0.0082146701	0.0098094021	0.0072739703	0.0097984319	-
.0043888734					
V3	0.0102008718	0.0121811896	0.0090327229	0.0121675670	-
.0054500467					
V4	0.0075036248	0.0089603201	0.0066443501	0.0089502995	-
.0040089814					
V5	0.0406534788	0.0485456283	0.0359980611	0.0484913382	
0.0241002562					
V6	0.0233034266	0.0278273722	0.0206348435	0.0277962520	
0.0138147723					

V7	0.0289999057	0.0346297213	0.0256789924	0.0345909938	0.0171917675
V8	0.0428174269	0.0511296684	0.0379142054	0.0510724885	0.0253830912
V9	0.0455622558	0.0544073570	0.0403447113	0.0543465116	0.0270102848
V10	0.0376591839	0.0449700443	0.0333466567	0.0449197529	0.0223251738
V11	0.2164296484	0.0645506933	0.0478663040	0.0644785043	0.0336200295
V12	0.0645506933	0.1716196329	0.0571586951	0.0769958585	0.0401467599
V13	0.0478663040	0.0571586951	0.1370184256	0.0570947728	0.0297700445
V14	0.0644785043	0.0769958585	0.0570947728	0.2513718769	0.0401018626
V15	0.0336200295	0.0401467599	0.0297700445	0.0401018626	0.3668846041

Determinant 3.997082E-12 Ln -26.245457

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Function	0.8277
Goodness of Fit Index (GFI)	0.8968
GFI Adjusted for Degrees of Freedom (AGFI)	0.8543
Root Mean Square Residual (RMR)	0.0144
Parsimonious GFI (Mulaik, 1989)	0.7260
Chi-Square	134.9112
Chi-Square DF	85
Pr > Chi-Square	0.0005
Independence Model Chi-Square	544.34
Independence Model Chi-Square DF	105
RMSEA Estimate	0.0600
RMSEA 90% Lower Confidence Limit	0.0400
RMSEA 90% Upper Confidence Limit	0.0786
ECVI Estimate	1.3039
ECVI 90% Lower Confidence Limit	1.1316
ECVI 90% Upper Confidence Limit	1.5307
Probability of Close Fit	0.1888
Bentler's Comparative Fit Index	0.8864
Normal Theory Reweighted LS Chi-Square	140.7284
Akaike's Information Criterion	-35.0888
Bozdogan's (1987) CAIC	-383.5774
Schwarz's Bayesian Criterion	-298.5774
McDonald's (1989) Centrality	0.8588
Bentler & Bonett's (1980) Non-normed Index	0.8597
Bentler & Bonett's (1980) NFI	0.7522
James, Mulaik, & Brett (1982) Parsimonious NFI	0.6089
Z-Test of Wilson & Hilferty (1931)	3.3070
Bollen (1986) Normed Index Rho1	0.6938
Bollen (1988) Non-normed Index Delta2	0.8913
Hoelter's (1983) Critical N	131

WARNING: The central parameter matrix _PHI_ has probably 1 negative eigenvalue(s).

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Raw Residual Matrix

	V1	V2	V3	V4	V5
V1	0.0000000000	0.0133511788	-.0019552646	-.0059899841	0.0099298356
V2	0.0133511788	0.0000000000	-.0080931304	-.0047926060	0.0292789953
V3	-.0019552646	-.0080931304	0.0000000000	0.0075629334	0.0337244146
V4	-.0059899841	-.0047926060	0.0075629334	0.0000000000	0.0273481365
V5	0.0099298356	0.0292789953	0.0337244146	0.0273481365	0.0000000000
V6	0.0062513754	0.0028134114	0.0212056716	0.0065766249	0.0158626384
V7	0.0164131359	0.0136153532	-.0266223020	-.0141987292	-.0203793208
V8	0.0111268310	0.0159448086	0.0244409943	-.0059101226	-.0204690490
V9	-.0353158031	-.0083629769	-.0086996954	-.0093728860	0.0020622700
V10	-.0274906193	-.0353745359	-.0211835657	-.0036481997	-.0065191835
V11	0.0171184342	0.0067538135	-.0191092647	-.0191144720	-.0198443419
V12	0.0025877832	0.0046848350	0.0044147046	0.0112795537	0.0194114316
V13	0.0032549695	-.0073097553	-.0180865771	-.0083600662	-.0163119025
V14	0.0061794666	0.0022132519	0.0030936352	0.0101448783	0.0350893743
V15	-.0170522078	0.0062520434	0.0066192608	0.0066734591	0.0133970836

Raw Residual Matrix

	V6	V7	V8	V9	V10
V1	0.0062513754	0.0164131359	0.0111268310	-.0353158031	-.0274906193
V2	0.0028134114	0.0136153532	0.0159448086	-.0083629769	-.0353745359
V3	0.0212056716	-.0266223020	0.0244409943	-.0086996954	-.0211835657
V4	0.0065766249	-.0141987292	-.0059101226	-.0093728860	-.0036481997
V5	0.0158626384	-.0203793208	-.0204690490	0.0020622700	-.0065191835
V6	0.0000000000	-.0295795687	0.0016852872	0.0123044984	-.0054399830
V7	-.0295795687	0.0000000000	0.0171691945	-.0146312257	0.0102974867
V8	0.0016852872	0.0171691945	0.0000000000	0.0079900292	-.0104560345
V9	0.0123044984	-.0146312257	0.0079900292	0.0000000000	0.0203784855
V10	-.0054399830	0.0102974867	-.0104560345	0.0203784855	0.0000000000
V11	-.0046105474	0.0324814293	0.0029666775	-.0136034587	-.0136350955
V12	-.0015051230	0.0236007183	0.0080297510	-.0127242468	0.0069319456
V13	-.0162898665	0.0211628822	-.0033032723	-.0214464171	0.0102448721
V14	-.0208226931	0.0150266587	-.0078442365	-.0015071107	-.0050506181
V15	0.0191532372	-.0182504946	-.0087356933	-.0252227613	0.0211200665

Raw Residual Matrix

	V11	V12	V13	V14	V15
V1	0.0171184342	0.0025877832	0.0032549695	0.0061794666	-.0170522078
V2	0.0067538135	0.0046848350	-.0073097553	0.0022132519	0.0062520434
V3	-.0191092647	0.0044147046	-.0180865771	0.0030936352	0.0066192608
V4	-.0191144720	0.0112795537	-.0083600662	0.0101448783	0.0066734591
V5	-.0198443419	0.0194114316	-.0163119025	0.0350893743	0.0133970836
V6	-.0046105474	-.0015051230	-.0162898665	-.0208226931	0.0191532372
V7	0.0324814293	0.0236007183	0.0211628822	0.0150266587	-.0182504946
V8	0.0029666775	0.0080297510	-.0033032723	-.0078442365	-.0087356933
V9	-.0136034587	-.0127242468	-.0214464171	-.0015071107	-.0252227613
V10	-.0136350955	0.0069319456	0.0102448721	-.0050506181	0.0211200665
V11	0.0000000000	0.0063958556	-.0021559871	-.0000742456	-.0012002733
V12	0.0063958556	0.0000000000	-.0017516522	-.0126849180	-.0006357187
V13	-.0021559871	-.0017516522	0.0000000000	0.0145734051	0.0003502750
V14	-.0000742456	-.0126849180	0.0145734051	0.0000000000	0.0017762745
V15	-.0012002733	-.0006357187	0.0003502750	0.0017762745	0.0000000000

Average Absolute Residual 0.010942
Average Off-diagonal Absolute Residual 0.012505

Rank Order of the 10 Largest Raw Residuals

Row	Column	Residual
V10	V2	-0.03537
V9	V1	-0.03532
V14	V5	0.03509
V5	V3	0.03372
V11	V7	0.03248
V7	V6	-0.02958
V5	V2	0.02928
V10	V1	-0.02749
V5	V4	0.02735
V7	V3	-0.02662

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Asymptotically Standardized Residual Matrix

	V1	V2	V3	V4	V5
V1	0.000000000	2.491948433	-0.730421402	-1.428714411	0.705372318
V2	2.491948433	0.000000000	-1.798711902	-0.760994209	1.944313334
V3	-0.730421402	-1.798711902	0.000000000	2.163378833	2.509259611
V4	-1.428714411	-0.760994209	2.163378833	0.000000000	2.126951751
V5	0.705372318	1.944313334	2.509259611	2.126951751	0.000000000
V6	0.539238923	0.233336312	1.897393727	0.634958512	1.576203978
V7	1.131104986	0.902443297	-1.902879833	-1.095478132	-1.616650933
V8	0.817004524	1.083901984	1.886391405	-0.471484367	-1.912982436
V9	-2.651937405	-0.574931607	-0.689569221	-0.757924805	0.203987057
V10	-2.168172475	-2.600207996	-1.751908982	-0.314263552	-0.641863938
V11	1.242324867	0.465203807	-1.445145026	-1.537012628	-1.369756294
V12	0.245937839	0.396237072	0.448145808	1.128517896	1.728238103
V13	0.309400490	-0.648897327	-1.801957718	-0.869360726	-1.471554123
V14	0.432612504	0.144844447	0.226921809	0.777581269	2.331744746
V15	-1.412952867	0.404965738	0.626192853	0.523105863	0.748761805

Asymptotically Standardized Residual Matrix

	V6	V7	V8	V9	V10
V1	0.539238923	1.131104986	0.817004524	-2.651937405	-2.168172475
V2	0.233336312	0.902443297	1.083901984	-0.574931607	-2.600207996
V3	1.897393727	-1.902879833	1.886391405	-0.689569221	-1.751908982
V4	0.634958512	-1.095478132	-0.471484367	-0.757924805	-0.314263552
V5	1.576203978	-1.616650933	-1.912982436	0.203987057	-0.641863938
V6	0.000000000	-2.696957870	0.176833592	1.355524365	-0.604121034
V7	-2.696957870	0.000000000	1.438142061	-1.286619660	0.912932048
V8	0.176833592	1.438142061	0.000000000	0.844883512	-1.095237407
V9	1.355524365	-1.286619660	0.844883512	0.000000000	2.261362286
V10	-0.604121034	0.912932048	-1.095237407	2.261362286	0.000000000
V11	-0.389594778	2.193004262	0.211038562	-0.986085356	-1.043991665
V12	-0.158516765	1.985238319	0.745984756	-1.222242393	0.687255830
V13	-1.782174624	1.849721500	-0.308131306	-2.046307371	1.026268675
V14	-1.678995911	0.968002863	-0.538875605	-0.105878187	-0.372653705
V15	1.231329614	-0.936852516	-0.515403147	-1.562105430	1.319082608

Asymptotically Standardized Residual Matrix

	V11	V12	V13	V14	V15
V1	1.242324867	0.245937839	0.309400490	0.432612504	-1.412952867
V2	0.465203807	0.396237072	-0.648897327	0.144844447	0.404965738
V3	-1.445145026	0.448145808	-1.801957718	0.226921809	0.626192853
V4	-1.537012628	1.128517896	-0.869360726	0.777581269	0.523105863
V5	-1.369756294	1.728238103	-1.471554123	2.331744746	0.748761805
V6	-0.389594778	-0.158516765	-1.782174624	-1.678995911	1.231329614
V7	2.193004262	1.985238319	1.849721500	0.968002863	-0.936852516
V8	0.211038562	0.745984756	-0.308131306	-0.538875605	-0.515403147
V9	-0.986085356	-1.222242393	-2.046307371	-0.105878187	-1.562105430
V10	-1.043991665	0.687255830	1.026268675	-0.372653705	1.319082608
V11	0.000000000	0.993503089	-0.281883109	-0.007126977	-0.071965585
V12	0.993503089	0.000000000	-0.389449095	-2.065647786	-0.059529577
V13	-0.281883109	-0.389449095	0.000000000	1.943050976	0.028559789
V14	-0.007126977	-2.065647786	1.943050976	0.000000000	0.106413470
V15	-0.071965585	-0.059529577	0.028559789	0.106413470	0.000000000

Average Standardized Residual 0.949484
Average Off-diagonal Standardized Residual 1.085125

Rank Order of the 10 Largest Asymptotically Standardized Residuals

Row	Column	Residual
V7	V6	-2.69696
V9	V1	-2.65194
V10	V2	-2.60021
V5	V3	2.50926
V2	V1	2.49195
V14	V5	2.33174
V10	V9	2.26136
V11	V7	2.19300
V10	V1	-2.16817
V4	V3	2.16338

Covariance Structure Analysis: Maximum Likelihood Estimation

Distribution of Asymptotically Standardized Residuals

Each * Represents 1 Residuals

----------Range---------		Freq	Percent	
-2.75000	-2.50000	3	2.50	***
-2.50000	-2.25000	0	0.00	
-2.25000	-2.00000	3	2.50	***
-2.00000	-1.75000	6	5.00	******
-1.75000	-1.50000	4	3.33	****
-1.50000	-1.25000	6	5.00	******
-1.25000	-1.00000	4	3.33	****
-1.00000	-0.75000	5	4.17	*****
-0.75000	-0.50000	8	6.67	********
-0.50000	-0.25000	7	5.83	*******
-0.25000	0	5	4.17	*****
0	0.25000	24	20.00	************************
0.25000	0.50000	6	5.00	******
0.50000	0.75000	8	6.67	********
0.75000	1.00000	7	5.83	*******
1.00000	1.25000	6	5.00	******
1.25000	1.50000	3	2.50	***
1.50000	1.75000	2	1.67	**
1.75000	2.00000	6	5.00	******
2.00000	2.25000	3	2.50	***
2.25000	2.50000	3	2.50	***
2.50000	2.75000	1	0.83	*

CORRELATION MATRIX 09:40 Tuesday, March 6, 2007
The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Estimates

V1 = 0.3170*F3 + 1.0000 E1
Std Err 0.0343 LV1F3
t Value 9.2449

V2 = 0.2612*F3 + 1.0000 E2
Std Err 0.0354 LV2F3
t Value 7.3762

V3 = 0.3243*F3 + 1.0000 E3
Std Err 0.0332 LV3F3
t Value 9.7542

V4 = 0.2385*F3 + 1.0000 E4
Std Err 0.0304 LV4F3
t Value 7.8471

V5 = 0.2678*F2 + 1.0000 E5
Std Err 0.0428 LV5F2
t Value 6.2526

V6 = 0.1535*F2 + 1.0000 E6
Std Err 0.0335 LV6F2
t Value 4.5826

V7 = 0.1910*F2 + 1.0000 E7
Std Err 0.0419 LV7F2
t Value 4.5587

V8 = 0.2820*F2 + 1.0000 E8
Std Err 0.0422 LV8F2
t Value 6.6834

V9 = 0.3001*F2 + 1.0000 E9
Std Err 0.0422 LV9F2
t Value 7.1186

V10 = 0.2481*F2 + 1.0000 E10
Std Err 0.0388 LV10F2
t Value 6.3941

V11 = 0.2325*F4 + 1.0000 E11
Std Err 0.0408 LV11F4
t Value 5.6946

V12 = 0.2776*F4 + 1.0000 E12
Std Err 0.0356 LV12F4
t Value 7.8012

V13 = 0.2059*F4 + 1.0000 E13
Std Err 0.0322 LV13F4
t Value 6.3995

V14 = 0.2773*F4 + 1.0000 E14
Std Err 0.0436 LV14F4
t Value 6.3614

V15 = 1.0000 F1 + 1.0000 E15

Variances of Exogenous Variables

Variable	Parameter	Standard Estimate	Error	t Value
F3		1.00000		
F2		1.00000		
F4		1.00000		
F1		1.00000		
E1	VARE1	0.09262	0.01502	6.17
E2	VARE2	0.12490	0.01635	7.64
E3	VARE3	0.07884	0.01422	5.55
E4	VARE4	0.08815	0.01195	7.38
E5	VARE5	0.17907	0.02327	7.70
E6	VARE6	0.12149	0.01448	8.39
E7	VARE7	0.19034	0.02267	8.40
E8	VARE8	0.16755	0.02250	7.45
E9	VARE9	0.16011	0.02240	7.15
E10	VARE10	0.14525	0.01907	7.62
E11	VARE11	0.16237	0.02080	7.81
E12	VARE12	0.09454	0.01576	6.00
E13	VARE13	0.09463	0.01284	7.37
E14	VARE14	0.17446	0.02359	7.40
E15	VARE15	-0.63312	0.04064	-15.58

Covariances Among Exogenous Variables

Var1	Var2	Parameter	Standard Estimate	Error	t Value
F3	F2	CF2F3	0.30597	0.09957	3.07
F3	F4	CF3F4	0.13529	0.10676	1.27
F2	F4	CF2F4	0.65294	0.08622	7.57
F3	F1	CF1F3	-0.01681	0.05360	-0.31
F2	F1	CF1F2	0.09000	0.05667	1.59
F4	F1	CF1F4	0.14460	0.05702	2.54

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Standardized Estimates

V1	=	0.7213*F3	+	0.6926 E1
		LV1F3		
V2	=	0.5943*F3	+	0.8042 E2
		LV2F3		
V3	=	0.7560*F3	+	0.6546 E3
		LV3F3		
V4	=	0.6263*F3	+	0.7796 E4
		LV4F3		
V5	=	0.5348*F2	+	0.8450 E5
		LV5F2		
V6	=	0.4030*F2	+	0.9152 E6
		LV6F2		
V7	=	0.4011*F2	+	0.9160 E7
		LV7F2		
V8	=	0.5674*F2	+	0.8234 E8
		LV8F2		
V9	=	0.6000*F2	+	0.8000 E9
		LV9F2		
V10	=	0.5455*F2	+	0.8381 E10
		LV10F2		
V11	=	0.4998*F4	+	0.8662 E11
		LV11F4		
V12	=	0.6702*F4	+	0.7422 E12
		LV12F4		
V13	=	0.5562*F4	+	0.8311 E13
		LV13F4		
V14	=	0.5531*F4	+	0.8331 E14
		LV14F4		
V15	=	1.6510 F1	+	1.0000 E15

Squared Multiple Correlations

	Variable	Error Variance	Total Variance	R-Square
1	V1	0.09262	0.19310	0.5203
2	V2	0.12490	0.19310	0.3532
3	V3	0.07884	0.18401	0.5715
4	V4	0.08815	0.14505	0.3923
5	V5	0.17907	0.25078	0.2860
6	V6	0.12149	0.14505	0.1624
7	V7	0.19034	0.22683	0.1609
8	V8	0.16755	0.24710	0.3219

9	V9	0.16011	0.25019	0.3600
10	V10	0.14525	0.20679	0.2976
11	V11	0.16237	0.21643	0.2498
12	V12	0.09454	0.17162	0.4491
13	V13	0.09463	0.13702	0.3093
14	V14	0.17446	0.25137	0.3060
15	V15	-0.63312	0.36688	2.7257

Correlations Among Exogenous Variables

Var1	Var2	Parameter	Estimate
F3	F2	CF2F3	0.30597
F3	F4	CF3F4	0.13529
F2	F4	CF2F4	0.65294
F3	F1	CF1F3	-0.01681
F2	F1	CF1F2	0.09000
F4	F1	CF1F4	0.14460

Stepwise Multivariate Wald Test

	------Cumulative Statistics-----			--Univariate Increment--	
Parameter	Chi-Square	DF	Pr > ChiSq	Chi-Square	Pr > ChiSq
CF1F3	0.09831	1	0.7539	0.09831	0.7539
CF3F4	1.93576	2	0.3799	1.83746	0.1752
CF1F2	4.99991	3	0.1718	3.06414	0.0800

```
PROC CALIS COVARIANCE CORR RESIDUAL MODIFICATION;
LINEQS
V1  = LV1F3 F3 + E1,
/*V2  = LV2F3 F3 + E2,*/
V3  = LV3F3 F3 + E3,
V4  = LV4F3 F3 + E4,
V5  = LV5F2 F2 + E5,
V6  = LV6F2 F2 + E6,
/*V7  = LV7F2 F2 + E7,*/
V8  = LV8F2 F2 + E8,
/*V9  = LV9F2 F2 + E9,
V10 = LV10F2 F2 + E10,*/
V11 = LV11F4 F4 + E11,
V12 = LV12F4 F4 + E12,
V13 = LV13F4 F4 + E13,
/*V14 = LV14F4 F4 + E14,*/
V15 = F1 + E15;
STD
F1 = 1,
F2 = 1,
F3 = 1,
F4 = 1,
E1 = VARE1,
E3-E6 = VARE3-VARE6,
E8 = VARE8,
E11-E13 = VARE11-VARE13,
E15 = VARE15;
COV
F1 F2 = CF1F2,
F1 F4 = CF1F4,
F2 F3 = CF2F3,
F2 F4 = CF2F4;
VAR V1 V3-V6 V8 V11-V14 V15;
RUN;
```

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The CALIS Procedure
Covariance Structure Analysis: Pattern and Initial Values

Automatic Variable Selection, the Following Manifest Variables are not Used in the Model V14

Using the VAR statement for variable selection could save memory and computing time.

LINEQS Model Statement

	Matrix	Rows	Columns	------Matrix Type-------	
Term 1	1 _SEL_	10	24	SELECTION	
	2 _BETA_	24	24	EQSBETA	IMINUSINV
	3 _GAMMA_	24	14	EQSGAMMA	
	4 _PHI_	14	14	SYMMETRIC	

The 10 Endogenous Variables

Manifest	V1	V3	V4	V5	V6	V8	V11	V12	V13	V15
Latent										

The 14 Exogenous Variables

Manifest				
Latent	F3	F2	F4	F1
Error	E1	E3	E4	E5	E6	E8	E11	E12	E13	E15

The CALIS Procedure
Covariance Structure Analysis: Pattern and Initial Values

Manifest Variable Equations with Initial Estimates

V1	=	.*F3	+ 1.0000 E1	
		LV1F3		
V3	=	.*F3	+ 1.0000 E3	
		LV3F3		
V4	=	.*F3	+ 1.0000 E4	
		LV4F3		
V5	=	.*F2	+ 1.0000 E5	
		LV5F2		
V6	=	.*F2	+ 1.0000 E6	
		LV6F2		
V8	=	.*F2	+ 1.0000 E8	
		LV8F2		
V11	=	.*F4	+ 1.0000 E11	
		LV11F4		
V12	=	.*F4	+ 1.0000 E12	
		LV12F4		
V13	=	.*F4	+ 1.0000 E13	
		LV13F4		
V15	=	1.0000 F1	+ 1.0000 E15	

Variances of Exogenous Variables

Variable	Parameter	Estimate
F3		1.00000
F2		1.00000
F4		1.00000
F1		1.00000
E1	VARE1	.
E3	VARE3	.
E4	VARE4	.
E5	VARE5	.
E6	VARE6	.
E8	VARE8	.
E11	VARE11	.
E12	VARE12	.
E13	VARE13	.
E15	VARE15	.

Covariances Among Exogenous Variables

Var1	Var2	Parameter	Estimate
F3	F2	CF2F3	.
F2	F4	CF2F4	.
F2	F1	CF1F2	.
F4	F1	CF1F4	.

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Observations	165	Model Terms	1
Variables	10	Model Matrices	4
Informations	55	Parameters	23

Variable	Mean	Std Dev
V1	0	0.43943
V3	0	0.42896
V4	0	0.38086
V5	0	0.50078
V6	0	0.38086
V8	0	0.49709
V11	0	0.46522
V12	0	0.41427
V13	0	0.37016
V15	0	0.60571

Covariances

	V1	V3	V4	V5	V6
V1	0.1930987249	0.1008388327	0.0696239785	0.0359024228	0.0211394070
V3	0.1008388327	0.1840066816	0.0849216522	0.0602963069	0.0364372376
V4	0.0696239785	0.0849216522	0.1450543396	0.0468940649	0.0177807609
V5	0.0359024228	0.0602963069	0.0468940649	0.2507806084	0.0569701760
V6	0.0211394070	0.0364372376	0.0177807609	0.0569701760	0.1450543396
V8	0.0384819157	0.0524272846	0.0146762180	0.0550614306	0.0449809421
V11	0.0270892346	-.0089083928	-.0116108472	0.0208091369	0.0186928792
V12	0.0144942371	0.0165958942	0.0202398737	0.0679570598	0.0263222492
V13	0.0120839675	-.0090538542	-.0017157161	0.0196861586	0.0043449770
V15	-.0223793336	0.0011692141	0.0026644777	0.0374973398	0.0329680095

Covariances

	V8	V11	V12	V13	V15
V1	0.0384819157	0.0270892346	0.0144942371	0.0120839675	-.0223793336
V3	0.0524272846	-.0089083928	0.0165958942	-.0090538542	0.0011692141
V4	0.0146762180	-.0116108472	0.0202398737	-.0017157161	0.0026644777
V5	0.0550614306	0.0208091369	0.0679570598	0.0196861586	0.0374973398
V6	0.0449809421	0.0186928792	0.0263222492	0.0043449770	0.0329680095
V8	0.2470984681	0.0457841044	0.0591594194	0.0346109332	0.0166473979
V11	0.0457841044	0.2164296484	0.0709465489	0.0457103169	0.0324197561
V12	0.0591594194	0.0709465489	0.1716196329	0.0554070429	0.0395110413
V13	0.0346109332	0.0457103169	0.0554070429	0.1370184256	0.0301203195

V15 0.0166473979 0.0324197561 0.0395110413 0.0301203195 0.3668846041

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Determinant 1.5879961E-8 Ln -17.958208

NOTE: Some initial estimates computed by instrumental variable method.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Vector of Initial Estimates

	Parameter	Estimate	Type
1	LV1F3	0.32719	Matrix Entry: _GAMMA_[1:1]
2	LV3F3	0.40696	Matrix Entry: _GAMMA_[2:1]
3	LV4F3	0.27066	Matrix Entry: _GAMMA_[3:1]
4	LV5F2	0.41298	Matrix Entry: _GAMMA_[4:2]
5	LV6F2	0.20469	Matrix Entry: _GAMMA_[5:2]
6	LV8F2	0.34526	Matrix Entry: _GAMMA_[6:2]
7	LV11F4	0.29988	Matrix Entry: _GAMMA_[7:3]
8	LV12F4	0.39202	Matrix Entry: _GAMMA_[8:3]
9	LV13F4	0.21570	Matrix Entry: _GAMMA_[9:3]
10	CF2F3	0.33773	Matrix Entry: _PHI_[2:1]
11	CF2F4	0.35448	Matrix Entry: _PHI_[3:2]
12	CF1F2	0.13929	Matrix Entry: _PHI_[4:2]
13	CF1F4	0.18043	Matrix Entry: _PHI_[4:3]
14	VARE1	0.08605	Matrix Entry: _PHI_[5:5]
15	VARE3	0.01839	Matrix Entry: _PHI_[6:6]
16	VARE4	0.07180	Matrix Entry: _PHI_[7:7]
17	VARE5	0.08022	Matrix Entry: _PHI_[8:8]
18	VARE6	0.10316	Matrix Entry: _PHI_[9:9]
19	VARE8	0.12790	Matrix Entry: _PHI_[10:10]
20	VARE11	0.12650	Matrix Entry: _PHI_[11:11]
21	VARE12	0.01794	Matrix Entry: _PHI_[12:12]
22	VARE13	0.09049	Matrix Entry: _PHI_[13:13]
23	VARE15	0.15546	Matrix Entry: _PHI_[14:14]

Predetermined Elements of the Predicted Moment Matrix

	V1	V3	V4	V5	V6
V1	.	.	.	.	.
V3	.	.	.	.	.
V4	.	.	.	.	.
V5	.	.	.	.	.
V6	.	.	.	.	.
V8	.	.	.	.	.
V11	0	0	0	.	.
V12	0	0	0	.	.
V13	0	0	0	.	.
V15	0	0	0	.	.

Predetermined Elements of the Predicted Moment Matrix

	V8	V11	V12	V13	V15
V1	.	0	0	0	0
V3	.	0	0	0	0
V4	.	0	0	0	0

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Predetermined Elements of the Predicted Moment Matrix

	V8	V11	V12	V13	V15
V5	.	.	.	.	.
V6	.	.	.	.	.
V8	.	.	.	.	.
V11	.	.	.	.	.
V12	.	.	.	.	.
V13	.	.	.	.	.
V15	.	.	.	.	.

WARNING: The predicted moment matrix has 12 constant elements whose values differ from those of the observed moment matrix. The sum of squared differences is 0.0025833963.

NOTE: Only 43 elements of the moment matrix are used in the model specification.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Levenberg-Marquardt Optimization

Scaling Update of More (1978)

Parameter Estimates	23
Functions (Observations)	55

Optimization Start

Active Constraints	0	Objective Function	1.3952540646
Max Abs Gradient Element	9.3417130151	Radius	188.87556781

Iter	Restarts	Function Calls	Active Constraints	Objective Function	Objective Function Change	Max Abs Gradient Element	Ratio Between Actual and Predicted Change	Lambda
1	0	2	0	0.21906	1.1762	0.3211	0	0.948
2	0	3	0	0.20596	0.0131	0.0683	0	1.186
3	0	4	0	0.20529	0.000671	0.0209	0	1.162
4	0	5	0	0.20522	0.000063	0.00405	0	1.101
5	0	6	0	0.20522	6.584E-6	0.00278	0	1.009
6	0	7	0	0.20522	7.628E-7	0.000387	0	0.908
7	0	8	0	0.20522	9.618E-8	0.000387	0	0.814
8	0	9	0	0.20522	1.315E-8	0.000073	0	0.739
9	0	10	0	0.20522	1.93E-9	0.000058	0	0.684
10	0	11	0	0.20522	2.99E-10	0.000015	0	0.646

Optimization Results

Iterations	10	Function Calls	12
Jacobian Calls	11	Active Constraints	0
Objective Function	0.2052166539	Max Abs Gradient Element	0.0000153051
Lambda	0	Actual Over Pred Change	0.6463869104
Radius	0.0001579666		

GCONV convergence criterion satisfied.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation
Predicted Model Matrix

	V1	V3	V4	V5	V6
V1	0.1930987249	0.1016287360	0.0636315857	0.0406478183	0.0239796332
V3	0.1016287360	0.1840066816	0.0859572040	0.0549094097	0.0323930670
V4	0.0636315857	0.0859572040	0.1450543396	0.0343797724	0.0202818839
V5	0.0406478183	0.0549094097	0.0343797724	0.2482846991	0.0464095625
V6	0.0239796332	0.0323930670	0.0202818839	0.0464095625	0.1441856309
V8	0.0345267628	0.0466407360	0.0292026066	0.0668222047	0.0394208600
V11	0.0000000000	0.0000000000	0.0000000000	0.0378748119	0.0223437354
V12	0.0000000000	0.0000000000	0.0000000000	0.0540365554	0.0318781383
V13	0.0000000000	0.0000000000	0.0000000000	0.0294427796	0.0173693714
V15	0.0000000000	0.0000000000	0.0000000000	0.0374517821	0.0220941746

Predicted Model Matrix

	V8	V11	V12	V13	V15
V1	0.0345267628	0.0000000000	0.0000000000	0.0000000000	0.0000000000
V3	0.0466407360	0.0000000000	0.0000000000	0.0000000000	0.0000000000
V4	0.0292026066	0.0000000000	0.0000000000	0.0000000000	0.0000000000
V5	0.0668222047	0.0378748119	0.0540365554	0.0294427796	0.0374517821
V6	0.0394208600	0.0223437354	0.0318781383	0.0173693714	0.0220941746
V8	0.2452977299	0.0321713366	0.0458993227	0.0250090634	0.0318120098
V11	0.0321713366	0.2164296484	0.0722521900	0.0393678925	0.0298978336

V12	0.0458993227	0.0722521900	0.1716196329	0.0561667556	0.0426556822
V13	0.0250090634	0.0393678925	0.0561667556	0.1370184256	0.0232417081
V15	0.0318120098	0.0298978336	0.0426556822	0.0232417081	0.3668846041

Determinant 1.9497274E-8 Ln -17.752991

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Function	0.2052
Goodness of Fit Index (GFI)	0.9604
GFI Adjusted for Degrees of Freedom (AGFI)	0.9319
Root Mean Square Residual (RMR)	0.0096
Parsimonious GFI (Mulaik, 1989)	0.6829
Chi-Square	33.6555
Chi-Square DF	32
Pr > Chi-Square	0.3872
Independence Model Chi-Square	278.00
Independence Model Chi-Square DF	45
RMSEA Estimate	0.0178
RMSEA 90% Lower Confidence Limit	.
RMSEA 90% Upper Confidence Limit	0.0614
ECVI Estimate	0.5059
ECVI 90% Lower Confidence Limit	.
ECVI 90% Upper Confidence Limit	0.6187
Probability of Close Fit	0.8608
Bentler's Comparative Fit Index	0.9929
Normal Theory Reweighted LS Chi-Square	33.8538
Akaike's Information Criterion	-30.3445
Bozdogan's (1987) CAIC	-161.7347
Schwarz's Bayesian Criterion	-129.7347
McDonald's (1989) Centrality	0.9950
Bentler & Bonett's (1980) Non-normed Index	0.9900
Bentler & Bonett's (1980) NFI	0.8789
James, Mulaik, & Brett (1982) Parsimonious NFI	0.6250
Z-Test of Wilson & Hilferty (1931)	0.2868
Bollen (1986) Normed Index Rho1	0.8298
Bollen (1988) Non-normed Index Delta2	0.9933
Hoelter's (1983) Critical N	227

WARNING: The central parameter matrix _PHI_ has probably 1 negative eigenvalue(s).

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Raw Residual Matrix

	V1	V3	V4	V5	V6
V1	0.0000000000	-.0007899033	0.0059923927	-.0047453955	-.0028402261
V3	-.0007899033	0.0000000000	-.0010355518	0.0053868972	0.0040441706
V4	0.0059923927	-.0010355518	0.0000000000	0.0125142925	-.0025011229
V5	-.0047453955	0.0053868972	0.0125142925	0.0024959093	0.0105606135
V6	-.0028402261	0.0040441706	-.0025011229	0.0105606135	0.0008687087
V8	0.0039551529	0.0057865485	-.0145263886	-.0117607741	0.0055600821
V11	0.0270892346	-.0089083928	-.0116108472	-.0170656750	-.0036508562
V12	0.0144942371	0.0165958942	0.0202398737	0.0139205045	-.0055558891
V13	0.0120839675	-.0090538542	-.0017157161	-.0097566210	-.0130243944
V15	-.0223793336	0.0011692141	0.0026644777	0.0000455578	0.0108738348

Raw Residual Matrix

	V8	V11	V12	V13	V15
V1	0.0039551529	0.0270892346	0.0144942371	0.0120839675	-.0223793336
V3	0.0057865485	-.0089083928	0.0165958942	-.0090538542	0.0011692141
V4	-.0145263886	-.0116108472	0.0202398737	-.0017157161	0.0026644777
V5	-.0117607741	-.0170656750	0.0139205045	-.0097566210	0.0000455578
V6	0.0055600821	-.0036508562	-.0055558891	-.0130243944	0.0108738348
V8	0.0018007382	0.0136127678	0.0132600967	0.0096018697	-.0151646119
V11	0.0136127678	0.0000000000	-.0013056411	0.0063424244	0.0025219226
V12	0.0132600967	-.0013056411	0.0000000000	-.0007597127	-.0031446409
V13	0.0096018697	0.0063424244	-.0007597127	0.0000000000	0.0068786114
V15	-.0151646119	0.0025219226	-.0031446409	0.0068786114	0.0000000000

Average Absolute Residual 0.007121

Average Off-diagonal Absolute Residual 0.008589

Rank Order of the 10 Largest Raw Residuals

Row	Column	Residual
V11	V1	0.02709
V15	V1	-0.02238
V12	V4	0.02024
V11	V5	-0.01707
V12	V3	0.01660
V15	V8	-0.01516
V8	V4	-0.01453
V12	V1	0.01449
V12	V5	0.01392
V11	V8	0.01361

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Asymptotically Standardized Residual Matrix

	V1	V3	V4	V5	V6
V1	0.000000000	-0.655913123	1.360182363	-0.367163191	-0.266097662
V3	-0.655913123	0.000000000	-0.917999339	0.561186719	0.468345195
V4	1.360182363	-0.917999339	0.000000000	1.101702654	-0.267759010
V5	-0.367163191	0.561186719	1.101702654	0.837042520	1.363217320
V6	-0.266097662	0.468345195	-0.267759010	1.363217320	0.837109558
V8	0.291646616	0.541391050	-1.222333178	-1.310036191	0.597061647
V11	1.696955985	-0.571670932	-0.839193463	-1.236255335	-0.317835192
V12	1.019633504	1.195975545	1.642785554	1.540862766	-0.677543868
V13	0.951376199	-0.730212288	-0.155852044	-0.878834367	-1.414819873
V15	-1.076749372	0.057628118	0.147912170	0.003039818	0.774662309

Asymptotically Standardized Residual Matrix

	V8	V11	V12	V13	V15
V1	0.291646616	1.696955985	1.019633504	0.951376199	-1.076749372
V3	0.541391050	-0.571670932	1.195975545	-0.730212288	0.057628118
V4	-1.222333178	-0.839193463	1.642785554	-0.155852044	0.147912170
V5	-1.310036191	-1.236255335	1.540862766	-0.878834367	0.003039818
V6	0.597061647	-0.317835192	-0.677543868	-1.414819873	0.774662309
V8	0.837012715	0.934477875	1.309846639	0.821577909	-0.878834326
V11	0.934477875	0.000000000	-0.487532058	0.823338239	0.149963103
V12	1.309846639	-0.487532058	0.000000000	-0.340042594	-0.517665020
V13	0.821577909	0.823338239	-0.340042594	0.000000000	0.507090953
V15	-0.878834326	0.149963103	-0.517665020	0.507090953	0.000000000

Average Standardized Residual 0.681879

Average Off-diagonal Standardized Residual 0.777605

Rank Order of the 10 Largest Asymptotically Standardized Residuals

Row	Column	Residual
V11	V1	1.69696
V12	V4	1.64279
V12	V5	1.54086
V13	V6	-1.41482
V6	V5	1.36322
V4	V1	1.36018
V8	V5	-1.31004
V12	V8	1.30985
V11	V5	-1.23626
V8	V4	-1.22233

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Distribution of Asymptotically Standardized Residuals

Each * Represents 1 Residuals

----------Range---------		Freq	Percent	
-1.50000	-1.25000	2	3.64	**
-1.25000	-1.00000	3	5.45	***
-1.00000	-0.75000	4	7.27	****
-0.75000	-0.50000	5	9.09	*****
-0.50000	-0.25000	6	10.91	******
-0.25000	0	1	1.82	*
0	0.25000	11	20.00	**********
0.25000	0.50000	2	3.64	**
0.50000	0.75000	4	7.27	****
0.75000	1.00000	8	14.55	********
1.00000	1.25000	3	5.45	***
1.25000	1.50000	3	5.45	***
1.50000	1.75000	3	5.45	***

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Estimates

V1	=	0.2743*F3	+ 1.0000 E1
Std Err		0.0358 LV1F3	
t Value		7.6689	
V3	=	0.3705*F3	+ 1.0000 E3
Std Err		0.0354 LV3F3	
t Value		10.4759	
V4	=	0.2320*F3	+ 1.0000 E4
Std Err		0.0310 LV4F3	
t Value		7.4825	
V5	=	0.2805*F2	+ 1.0000 E5
Std Err		0.0473 LV5F2	
t Value		5.9299	
V6	=	0.1655*F2	+ 1.0000 E6
Std Err		0.0355 LV6F2	
t Value		4.6545	
V8	=	0.2382*F2	+ 1.0000 E8
Std Err		0.0463 LV8F2	
t Value		5.1413	
V11	=	0.2250*F4	+ 1.0000 E11
Std Err		0.0429 LV11F4	
t Value		5.2459	
V12	=	0.3211*F4	+ 1.0000 E12
Std Err		0.0426 LV12F4	
t Value		7.5431	
V13	=	0.1749*F4	+ 1.0000 E13
Std Err		0.0341 LV13F4	
t Value		5.1326	
V15	=	1.0000 F1	+ 1.0000 E15

Variances of Exogenous Variables

Variable	Parameter	Standard Estimate	Error	t Value
F3		1.00000		
F2		1.00000		
F4		1.00000		
F1		1.00000		
E1	VARE1	0.11787	0.01640	7.19
E3	VARE3	0.04672	0.01809	2.58
E4	VARE4	0.09123	0.01238	7.37
E5	VARE5	0.16962	0.02575	6.59
E6	VARE6	0.11681	0.01479	7.90
E8	VARE8	0.18854	0.02501	7.54
E11	VARE11	0.16579	0.02172	7.63
E12	VARE12	0.06854	0.02241	3.06

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Variances of Exogenous Variables

Variable	Parameter	Standard Estimate	Error	t Value
E13	VARE13	0.10641	0.01376	7.73
E15	VARE15	-0.63312	0.04052	-15.63

Covariances Among Exogenous Variables

Var1	Var2	Parameter	Standard Estimate	Error	t Value
F3	F2	CF2F3	0.52836	0.10290	5.13
F2	F4	CF2F4	0.60006	0.11433	5.25
F2	F1	CF1F2	0.13353	0.06276	2.13
F4	F1	CF1F4	0.13286	0.05712	2.33

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Standardized Estimates

V1	=	0.6242*F3	+	0.7813 E1
		LV1F3		
V3	=	0.8638*F3	+	0.5039 E3
		LV3F3		
V4	=	0.6091*F3	+	0.7931 E4
		LV4F3		
V5	=	0.5629*F2	+	0.8265 E5
		LV5F2		
V6	=	0.4358*F2	+	0.9001 E6
		LV6F2		
V8	=	0.4810*F2	+	0.8767 E8
		LV8F2		
V11	=	0.4837*F4	+	0.8752 E11
		LV11F4		
V12	=	0.7750*F4	+	0.6319 E12
		LV12F4		
V13	=	0.4726*F4	+	0.8813 E13
		LV13F4		
V15	=	1.6510 F1	+	1.0000 E15

Squared Multiple Correlations

	Variable	Error Variance	Total Variance	R-Square
1	V1	0.11787	0.19310	0.3896
2	V3	0.04672	0.18401	0.7461
3	V4	0.09123	0.14505	0.3710
4	V5	0.16962	0.24828	0.3168
5	V6	0.11681	0.14419	0.1899
6	V8	0.18854	0.24530	0.2314
7	V11	0.16579	0.21643	0.2340
8	V12	0.06854	0.17162	0.6006
9	V13	0.10641	0.13702	0.2234
10	V15	-0.63312	0.36688	2.7257

Correlations Among Exogenous Variables

Var1	Var2	Parameter	Estimate
F3	F2	CF2F3	0.52836
F2	F4	CF2F4	0.60006
F2	F1	CF1F2	0.13353
F4	F1	CF1F4	0.13286

PROC CALIS COVARIANCE CORR RESIDUAL MODIFICATION;
LINEQS
V1 = LV1F3 F3 + E1,
V3 = F3 + E3,
V4 = LV4F3 F3 + E4,
V5 = F2 + E5,
V6 = LV6F2 F2 + E6,
V8 = LV8F2 F2 + E8,
V11 = LV11F4 F4 + E11,
V12 = F4 + E12,
V13 = LV13F4 F4 + E13,
V15 = F1,
F1 = PF1F2 F2 + PF1F4 F4 + D1,
F2 = PF2F3 F3 + PF2F4 F4 + D2;
STD
E1 = VARE1,
E3-E6 = VARE3-VARE6,
E8 = VARE8,
E11-E13 = VARE11-VARE13,
F3 = VARF3,
F4 = VARF4,
D1 = VARD1,
D2 = VARD2;
VAR V1-V6 V8 V11-V13 V15;
RUN;

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The CALIS Procedure

Covariance Structure Analysis: Pattern and Initial Values

Automatic Variable Selection, the Following Manifest Variables are not Used in the Model V2

Using the VAR statement for variable selection could save memory and computing time.

LINEQS Model Statement

	Matrix	Rows	Columns	------Matrix Type-------	
Term 1	1 _SEL_	10	25	SELECTION	
	2 _BETA_	25	25	EQSBETA	IMINUSINV
	3 _GAMMA_	25	13	EQSGAMMA	
	4 _PHI_	13	13	SYMMETRIC	

The 12 Endogenous Variables

Manifest	V1	V3	V4	V5	V6	V8	V11	V12	V13	V15
Latent	F1	F2								

The 13 Exogenous Variables

Manifest	
Latent	F3 F4
Error	E1 E3 E4 E5 E6 E8 E11 E12 E13 D1 D2

The CALIS Procedure

Covariance Structure Analysis: Pattern and Initial Values

Manifest Variable Equations with Initial Estimates

V1	=	.*F3	+	1.0000 E1	
		LV1F3			
V3	=	1.0000 F3	+	1.0000 E3	
V4	=	.*F3	+	1.0000 E4	
		LV4F3			
V5	=	1.0000 F2	+	1.0000 E5	
V6	=	.*F2	+	1.0000 E6	
		LV6F2			
V8	=	.*F2	+	1.0000 E8	
		LV8F2			
V11	=	.*F4	+	1.0000 E11	
		LV11F4			
V12	=	1.0000 F4	+	1.0000 E12	
V13	=	.*F4	+	1.0000 E13	
		LV13F4			
V15	=	1.0000 F1			

The CALIS Procedure

Covariance Structure Analysis: Pattern and Initial Values

Latent Variable Equations with Initial Estimates

F1	=	.*F2	+	.*F4	+	1.0000 D1
		PF1F2		PF1F4		
F2	=	.*F3	+	.*F4	+	1.0000 D2
		PF2F3		PF2F4		

Variances of Exogenous Variables

Variable	Parameter	Estimate
F3	VARF3	.
F4	VARF4	.
E1	VARE1	.
E3	VARE3	.
E4	VARE4	.
E5	VARE5	.
E6	VARE6	.
E8	VARE8	.
E11	VARE11	.
E12	VARE12	.
E13	VARE13	.
D1	VARD1	.
D2	VARD2	.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Observations	165	Model Terms	1
Variables	10	Model Matrices	4
Informations	55	Parameters	23

Variable	Mean	Std Dev
V1	0	0.43943
V3	0	0.42896
V4	0	0.38086
V5	0	0.50078
V6	0	0.38086
V8	0	0.49709
V11	0	0.46522
V12	0	0.41427
V13	0	0.37016
V15	0	0.60571

Covariances

	V1	V3	V4	V5	V6
V1	0.1930987249	0.1008388327	0.0696239785	0.0359024228	0.0211394070
V3	0.1008388327	0.1840066816	0.0849216522	0.0602963069	0.0364372376
V4	0.0696239785	0.0849216522	0.1450543396	0.0468940649	0.0177807609
V5	0.0359024228	0.0602963069	0.0468940649	0.2507806084	0.0569701760
V6	0.0211394070	0.0364372376	0.0177807609	0.0569701760	0.1450543396
V8	0.0384819157	0.0524272846	0.0146762180	0.0550614306	0.0449809421
V11	0.0270892346	-.0089083928	-.0116108472	0.0208091369	0.0186928792
V12	0.0144942371	0.0165958942	0.0202398737	0.0679570598	0.0263222492
V13	0.0120839675	-.0090538542	-.0017157161	0.0196861586	0.0043449770
V15	-.0223793336	0.0011692141	0.0026644777	0.0374973398	0.0329680095

Covariances

	V8	V11	V12	V13	V15
V1	0.0384819157	0.0270892346	0.0144942371	0.0120839675	-.0223793336
V3	0.0524272846	-.0089083928	0.0165958942	-.0090538542	0.0011692141
V4	0.0146762180	-.0116108472	0.0202398737	-.0017157161	0.0026644777
V5	0.0550614306	0.0208091369	0.0679570598	0.0196861586	0.0374973398
V6	0.0449809421	0.0186928792	0.0263222492	0.0043449770	0.0329680095
V8	0.2470984681	0.0457841044	0.0591594194	0.0346109332	0.0166473979
V11	0.0457841044	0.2164296484	0.0709465489	0.0457103169	0.0324197561
V12	0.0591594194	0.0709465489	0.1716196329	0.0554070429	0.0395110413
V13	0.0346109332	0.0457103169	0.0554070429	0.1370184256	0.0301203195

V15 0.0166473979 0.0324197561 0.0395110413 0.0301203195 0.3668846041

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Determinant 1.5879961E-8 Ln -17.958208

NOTE: Some initial estimates computed by instrumental variable method.

NOTE: Some initial estimates computed by two-stage LS method.

Vector of Initial Estimates

	Parameter	Estimate	Type
1	LV6F2	0.55428	Matrix Entry: _BETA_[5:12]
2	LV8F2	0.76552	Matrix Entry: _BETA_[6:12]
3	PF1F2	-0.24459	Matrix Entry: _BETA_[11:12]
4	LV1F3	0.80315	Matrix Entry: _GAMMA_[1:1]
5	LV4F3	0.61319	Matrix Entry: _GAMMA_[3:1]
6	LV11F4	0.58322	Matrix Entry: _GAMMA_[7:2]
7	LV13F4	0.42347	Matrix Entry: _GAMMA_[9:2]
8	PF1F4	0.47840	Matrix Entry: _GAMMA_[11:2]
9	PF2F3	0.39366	Matrix Entry: _GAMMA_[12:1]
10	PF2F4	0.45289	Matrix Entry: _GAMMA_[12:2]
11	VARF3	0.13244	Matrix Entry: _PHI_[1:1]
12	VARF4	0.13115	Matrix Entry: _PHI_[2:2]
13	VARE1	0.10767	Matrix Entry: _PHI_[3:3]
14	VARE3	0.05157	Matrix Entry: _PHI_[4:4]
15	VARE4	0.09526	Matrix Entry: _PHI_[5:5]
16	VARE5	0.16430	Matrix Entry: _PHI_[6:6]
17	VARE6	0.11849	Matrix Entry: _PHI_[7:7]
18	VARE8	0.19642	Matrix Entry: _PHI_[8:8]
19	VARE11	0.17182	Matrix Entry: _PHI_[9:9]
20	VARE12	0.04047	Matrix Entry: _PHI_[10:10]
21	VARE13	0.11350	Matrix Entry: _PHI_[11:11]
22	VARD1	0.35974	Matrix Entry: _PHI_[12:12]
23	VARD2	0.03396	Matrix Entry: _PHI_[13:13]

Predetermined Elements of the Predicted Moment Matrix

	V1	V3	V4	V5	V6
V1	.	.	.	.	.
V3	.	.	.	.	.
V4	.	.	.	.	.
V5	.	.	.	.	.
V6	.	.	.	.	.

V8	.	.	.	.	.
V11	0	0	0	.	.
V12	0	0	0	.	.
V13	0	0	0	.	.
V15	.	.	.	.	.

Predetermined Elements of the Predicted Moment Matrix

	V8	V11	V12	V13	V15
V1	.	0	0	0	.
V3	.	0	0	0	.
V4	.	0	0	0	.
V5	.	.	.	.	.
V6	.	.	.	.	.
V8	.	.	.	.	.
V11	.	.	.	.	.
V12	.	.	.	.	.
V13	.	.	.	.	.
V15	.	.	.	.	.

WARNING: The predicted moment matrix has 9 constant elements whose values differ from those of the observed moment matrix. The sum of squared differences is 0.0020740952.

NOTE: Only 46 elements of the moment matrix are used in the model specification.

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Levenberg-Marquardt Optimization
Scaling Update of More (1978)

Parameter Estimates 23
Functions (Observations) 55

Optimization Start

Active Constraints 0 Objective Function 0.2368104747
Max Abs Gradient Element 0.5712920506 Radius 6.7884311243

Iter	Restarts	Function Calls	Active Constraints	Objective Function	Objective Function Change	Max Abs Gradient Element	Lambda	Ratio Between Actual and Predicted Change

1	0	2	0	0.21184	0.0250	0.2138	0	0.941
2	0	3	0	0.20986	0.00199	0.0169	0	1.013
3	0	4	0	0.20983	0.000030	0.00393	0	1.081
4	0	5	0	0.20983	1.778E-6	0.000951	0	1.123
5	0	6	0	0.20983	1.306E-7	0.000305	0	1.123
6	0	7	0	0.20983	1.076E-8	0.000116	0	1.075
7	0	8	0	0.20983	9.94E-10	0.000039	0	0.983

Optimization Results

Iterations	7	Function Calls	9
Jacobian Calls	8	Active Constraints	0
Objective Function	0.2098250768	Max Abs Gradient Element	0.0000389679
Lambda	0	Actual Over Pred Change	0.9833174177
Radius	0.0002906044		

GCONV convergence criterion satisfied.

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Predicted Model Matrix

	V1	V3	V4	V5	V6
V1	0.1930987249	0.1015702181	0.0631648145	0.0400465926	0.0234509643
V3	0.1015702181	0.1840066816	0.0860781623	0.0545736914	0.0319579173
V4	0.0631648145	0.0860781623	0.1450543396	0.0339384631	0.0198740926
V5	0.0400465926	0.0545736914	0.0339384631	0.2482534324	0.0456115350
V6	0.0234509643	0.0319579173	0.0198740926	0.0456115350	0.1441878045
V8	0.0347448168	0.0473486703	0.0294453437	0.0675777934	0.0395730154
V11	0.0000000000	0.0000000000	0.0000000000	0.0387461674	0.0226894458
V12	0.0000000000	0.0000000000	0.0000000000	0.0541492468	0.0317093659
V13	0.0000000000	0.0000000000	0.0000000000	0.0301407513	0.0176501829
V15	0.0023808878	0.0032445666	0.0020177415	0.0272158403	0.0159373784

Predicted Model Matrix

	V8	V11	V12	V13	V15
V1	0.0347448168	0.0000000000	0.0000000000	0.0000000000	0.0023808878
V3	0.0473486703	0.0000000000	0.0000000000	0.0000000000	0.0032445666
V4	0.0294453437	0.0000000000	0.0000000000	0.0000000000	0.0020177415
V5	0.0675777934	0.0387461674	0.0541492468	0.0301407513	0.0272158403
V6	0.0395730154	0.0226894458	0.0317093659	0.0176501829	0.0159373784
V8	0.2451961766	0.0336165551	0.0469804180	0.0261504117	0.0236127302
V11	0.0336165551	0.2164296483	0.0716626640	0.0398891335	0.0321933068
V12	0.0469804180	0.0716626640	0.1716196329	0.0557465855	0.0449913741
V13	0.0261504117	0.0398891335	0.0557465855	0.1370184255	0.0250432628
V15	0.0236127302	0.0321933068	0.0449913741	0.0250432628	0.3667597823

Determinant 1.9587333E-8 Ln -17.748383

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Function	0.2098
Goodness of Fit Index (GFI)	0.9591
GFI Adjusted for Degrees of Freedom (AGFI)	0.9297
Root Mean Square Residual (RMR)	0.0098
Parsimonious GFI (Mulaik, 1989)	0.6820
Chi-Square	34.4113
Chi-Square DF	32
Pr > Chi-Square	0.3530
Independence Model Chi-Square	278.00
Independence Model Chi-Square DF	45
RMSEA Estimate	0.0214
RMSEA 90% Lower Confidence Limit	.
RMSEA 90% Upper Confidence Limit	0.0630
ECVI Estimate	0.5105
ECVI 90% Lower Confidence Limit	.
ECVI 90% Upper Confidence Limit	0.6251
Probability of Close Fit	0.8414
Bentler's Comparative Fit Index	0.9897
Normal Theory Reweighted LS Chi-Square	34.9478
Akaike's Information Criterion	-29.5887
Bozdogan's (1987) CAIC	-160.9789
Schwarz's Bayesian Criterion	-128.9789
McDonald's (1989) Centrality	0.9927
Bentler & Bonett's (1980) Non-normed Index	0.9854
Bentler & Bonett's (1980) NFI	0.8762
James, Mulaik, & Brett (1982) Parsimonious NFI	0.6231
Z-Test of Wilson & Hilferty (1931)	0.3775
Bollen (1986) Normed Index Rho1	0.8259
Bollen (1988) Non-normed Index Delta2	0.9902
Hoelter's (1983) Critical N	222

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Raw Residual Matrix

	V1	V3	V4	V5	V6
V1	0.0000000000	-.0007313854	0.0064591640	-.0041441698	-.0023115573
V3	-.0007313854	0.0000000000	-.0011565102	0.0057226155	0.0044793203
V4	0.0064591640	-.0011565102	0.0000000000	0.0129556018	-.0020933316
V5	-.0041441698	0.0057226155	0.0129556018	0.0025271760	0.0113586411
V6	-.0023115573	0.0044793203	-.0020933316	0.0113586411	0.0008665351
V8	0.0037370989	0.0050786143	-.0147691257	-.0125163628	0.0054079267

V11	0.0270892346	-.0089083928	-.0116108472	-.0179370305	-.0039965666
V12	0.0144942371	0.0165958942	0.0202398737	0.0138078130	-.0053871166
V13	0.0120839675	-.0090538542	-.0017157161	-.0104545927	-.0133052059
V15	-.0247602214	-.0020753525	0.0006467362	0.0102814995	0.0170306310

Raw Residual Matrix

	V8	V11	V12	V13	V15
V1	0.0037370989	0.0270892346	0.0144942371	0.0120839675	-.0247602214
V3	0.0050786143	-.0089083928	0.0165958942	-.0090538542	-.0020753525
V4	-.0147691257	-.0116108472	0.0202398737	-.0017157161	0.0006467362
V5	-.0125163628	-.0179370305	0.0138078130	-.0104545927	0.0102814995
V6	0.0054079267	-.0039965666	-.0053871166	-.0133052059	0.0170306310
V8	0.0019022915	0.0121675493	0.0121790014	0.0084605215	-.0069653322
V11	0.0121675493	0.0000000000	-.0007161151	0.0058211834	0.0002264494
V12	0.0121790014	-.0007161151	0.0000000000	-.0003395426	-.0054803329
V13	0.0084605215	0.0058211834	-.0003395426	0.0000000000	0.0050770567
V15	-.0069653322	0.0002264494	-.0054803329	0.0050770567	0.0001248218

Average Absolute Residual 0.007223
Average Off-diagonal Absolute Residual 0.008707

Rank Order of the 10 Largest Raw Residuals

Row	Column	Residual
V11	V1	0.02709
V15	V1	-0.02476
V12	V4	0.02024
V11	V5	-0.01794
V15	V6	0.01703
V12	V3	0.01660
V8	V4	-0.01477
V12	V1	0.01449
V12	V5	0.01381
V13	V6	-0.01331

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation
Asymptotically Standardized Residual Matrix

	V1	V3	V4	V5	V6
V1	0.000000000	-0.625729008	1.456149913	-0.319564053	-0.215639506
V3	-0.625729008	0.000000000	-1.063129513	0.599102870	0.518221123
V4	1.456149913	-1.063129513	0.000000000	1.138124298	-0.223355668
V5	-0.319564053	0.599102870	1.138124298	0.876192080	1.444879697
V6	-0.215639506	0.518221123	-0.223355668	1.444879697	0.876112184

V8	0.276601212	0.483151390	-1.248270965	-1.423757113	0.586486472
V11	1.696955986	-0.571670932	-0.839193463	-1.303878074	-0.348778198
V12	1.019633504	1.195975545	1.642785554	1.523401665	-0.655798085
V13	0.951376199	-0.730212288	-0.155852044	-0.945367033	-1.449119253
V15	-1.444605778	-0.166557569	0.043093763	0.630628925	1.154329780

Asymptotically Standardized Residual Matrix

	V8	V11	V12	V13	V15
V1	0.276601212	1.696955986	1.019633504	0.951376199	-1.444605778
V3	0.483151390	-0.571670932	1.195975545	-0.730212288	-0.166557569
V4	-1.248270965	-0.839193463	1.642785554	-0.155852044	0.043093763
V5	-1.423757113	-1.303878074	1.523401665	-0.945367033	0.630628925
V6	0.586486472	-0.348778198	-0.655798085	-1.449119253	1.154329780
V8	0.876177295	0.844715085	1.220373701	0.732076419	-0.386461541
V11	0.844715085	0.000000000	-0.238550525	0.749775442	0.013513894
V12	1.220373701	-0.238550525	0.000000000	-0.136226635	-0.794818948
V13	0.732076419	0.749775442	-0.136226635	0.000000000	0.375834179
V15	-0.386461541	0.013513894	-0.794818948	0.375834179	0.876080301

Average Standardized Residual 0.710696
Average Off-diagonal Standardized Residual 0.790749

Rank Order of the 10 Largest Asymptotically Standardized Residuals

Row	Column	Residual
V11	V1	1.69696
V12	V4	1.64279
V12	V5	1.52340
V4	V1	1.45615
V13	V6	-1.44912
V6	V5	1.44488
V15	V1	-1.44461
V8	V5	-1.42376
V11	V5	-1.30388
V8	V4	-1.24827

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation
Distribution of Asymptotically Standardized Residuals
Each * Represents 1 Residuals

----------Range---------		Freq	Percent	
-1.50000	-1.25000	4	7.27	****
-1.25000	-1.00000	2	3.64	**
-1.00000	-0.75000	3	5.45	***
-0.75000	-0.50000	4	7.27	****
-0.50000	-0.25000	3	5.45	***
-0.25000	0	6	10.91	******
0	0.25000	8	14.55	********
0.25000	0.50000	3	5.45	***
0.50000	0.75000	6	10.91	******
0.75000	1.00000	6	10.91	******
1.00000	1.25000	5	9.09	*****
1.25000	1.50000	2	3.64	**
1.50000	1.75000	3	5.45	***

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation
Manifest Variable Equations with Estimates

V1 = 0.7338*F3 + 1.0000 E1
Std Err 0.1174 LV1F3
t Value 6.2523
V3 = 1.0000 F3 + 1.0000 E3
V4 = 0.6219*F3 + 1.0000 E4
Std Err 0.1007 LV4F3
t Value 6.1746
V5 = 1.0000 F2 + 1.0000 E5
V6 = 0.5856*F2 + 1.0000 E6
Std Err 0.1569 LV6F2
t Value 3.7316
V8 = 0.8676*F2 + 1.0000 E8
Std Err 0.2145 LV8F2
t Value 4.0443
V11 = 0.7155*F4 + 1.0000 E11
Std Err 0.1714 LV11F4
t Value 4.1743
V12 = 1.0000 F4 + 1.0000 E12
V13 = 0.5566*F4 + 1.0000 E13
Std Err 0.1349 LV13F4
t Value 4.1256
V15 = 1.0000 F1

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Latent Variable Equations with Estimates

F1	=	0.0595*F2	+	0.4171*F4	+	1.0000 D1
Std Err		0.2930 PF1F2		0.2608 PF1F4		
t Value		0.2029		1.5992		
F2	=	0.3943*F3	+	0.5407*F4	+	1.0000 D2
Std Err		0.1007 PF2F3		0.1482 PF2F4		
t Value		3.9147		3.6479		

Variances of Exogenous Variables

Variable	Parameter	Estimate	Standard Error	t Value
F3	VARF3	0.13842	0.02639	5.25
F4	VARF4	0.10015	0.02632	3.81
E1	VARE1	0.11857	0.01643	7.21
E3	VARE3	0.04559	0.01828	2.49
E4	VARE4	0.09152	0.01240	7.38
E5	VARE5	0.17036	0.02580	6.60
E6	VARE6	0.11748	0.01484	7.92
E8	VARE8	0.18657	0.02506	7.45
E11	VARE11	0.16515	0.02166	7.63
E12	VARE12	0.07147	0.02140	3.34
E13	VARE13	0.10599	0.01373	7.72
D1	VARD1	0.34638	0.03925	8.83
D2	VARD2	0.02710	0.01726	1.57

Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Standardized Estimates

V1	=	0.6213*F3	+	0.7836 E1
		LV1F3		
V3	=	0.8673 F3	+	0.4978 E3
V4	=	0.6075*F3	+	0.7943 E4
		LV4F3		
V5	=	0.5601 F2	+	0.8284 E5
V6	=	0.4304*F2	+	0.9026 E6
		LV6F2		
V8	=	0.4890*F2	+	0.8723 E8
		LV8F2		
V11	=	0.4868*F4	+	0.8735 E11
		LV11F4		
V12	=	0.7639 F4	+	0.6453 E12
V13	=	0.4759*F4	+	0.8795 E13
		LV13F4		
V15	=	1.0000 F1		

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Latent Variable Equations with Standardized Estimates

F1 = 0.0274*F2 + 0.2180*F4 + 0.9718 D1
PF1F2 PF1F4

F2 = 0.5256*F3 + 0.6131*F4 + 0.5898 D2
PF2F3 PF2F4

Squared Multiple Correlations

	Variable	Error Variance	Total Variance	R-Square
1	V1	0.11857	0.19310	0.3860
2	V3	0.04559	0.18401	0.7522
3	V4	0.09152	0.14505	0.3690
4	V5	0.17036	0.24825	0.3138
5	V6	0.11748	0.14419	0.1852
6	V8	0.18657	0.24520	0.2391
7	V11	0.16515	0.21643	0.2369
8	V12	0.07147	0.17162	0.5836
9	V13	0.10599	0.13702	0.2265
10	V15	.	0.36676	.
11	F1	0.34638	0.36676	0.0556
12	F2	0.02710	0.07789	0.6521

Stepwise Multivariate Wald Test

	------Cumulative Statistics-----			--Univariate Increment--	
Parameter	Chi-Square	DF	Pr > ChiSq	Chi-Square	Pr > ChiSq
PF1F2	0.04118	1	0.8392	0.04118	0.8392
VARD2	2.49589	2	0.2871	2.45471	0.1172

```
PROC CALIS COVARIANCE CORR RESIDUAL MODIFICATION;
LINEQS
V1  =  LV1F3 F3 + E1,
V3  =      F3 + E3,
V4  =  LV4F3 F3 + E4,
V5  =      F2 + E5,
V6  =  LV6F2 F2 + E6,
V8  =  LV8F2 F2 + E8,
V11 = LV11F4 F4 + E11,
V12 =      F4 + E12,
V13 = LV13F4 F4 + E13,
V15 = F1,
F1 = PF1F4 F4 + D1,
F2 = PF2F3 F3 + PF2F4 F4 + D2;
STD
E1 = VARE1,
E3-E6 = VARE3-VARE6,
E8 = VARE8,
E11-E13 = VARE11-VARE13,
F3 = VARF3,
F4 = VARF4,
D1 = VARD1,
D2 = VARD2;
VAR V1-V6 V8 V11-V13 V15;
RUN;
```

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The CALIS Procedure
Covariance Structure Analysis: Pattern and Initial Values
Automatic Variable Selection, the Following Manifest Variables are not Used in the Model V2

Using the VAR statement for variable selection could save memory and computing time.

LINEQS Model Statement

	Matrix	Rows	Columns	------Matrix Type-------	
Term 1	1 _SEL_	10	25	SELECTION	
	2 _BETA_	25	25	EQSBETA	IMINUSINV
	3 _GAMMA_	25	13	EQSGAMMA	
	4 _PHI_	13	13	SYMMETRIC	

The 12 Endogenous Variables

Manifest	V1	V3	V4	V5	V6	V8	V11	V12	V13	V15
Latent	F1	F2								

The 13 Exogenous Variables

Manifest
Latent F3 F4
Error E1 E3 E4 E5 E6 E8 E11 E12 E13 D1 D2

The CALIS Procedure

Covariance Structure Analysis: Pattern and Initial Values

Manifest Variable Equations with Initial Estimates

```
V1  =    .*F3   + 1.0000 E1
        LV1F3
V3  = 1.0000 F3  + 1.0000 E3
V4  =    .*F3   + 1.0000 E4
        LV4F3
V5  = 1.0000 F2  + 1.0000 E5
V6  =    .*F2   + 1.0000 E6
        LV6F2
V8  =    .*F2   + 1.0000 E8
        LV8F2
V11 =    .*F4   + 1.0000 E11
        LV11F4
V12 = 1.0000 F4  + 1.0000 E12
V13 =    .*F4   + 1.0000 E13
        LV13F4
V15 = 1.0000 F1

F1  =    .*F4   + 1.0000 D1
        PF1F4
F2  =    .*F3   +    .*F4   + 1.0000 D2
        PF2F3       PF2F4
```

Variances of Exogenous Variables

Variable	Parameter	Estimate
F3	VARF3	.
F4	VARF4	.
E1	VARE1	.
E3	VARE3	.
E4	VARE4	.
E5	VARE5	.
E6	VARE6	.
E8	VARE8	.
E11	VARE11	.
E12	VARE12	.
E13	VARE13	.
D1	VARD1	.
D2	VARD2	.

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Observations	165	Model Terms	1
Variables	10	Model Matrices	4
Informations	55	Parameters	22

Variable	Mean	Std Dev
V1	0	0.43943
V3	0	0.42896
V4	0	0.38086
V5	0	0.50078
V6	0	0.38086
V8	0	0.49709
V11	0	0.46522
V12	0	0.41427
V13	0	0.37016
V15	0	0.60571

Covariances

	V1	V3	V4	V5	V6
V1	0.1930987249	0.1008388327	0.0696239785	0.0359024228	0.0211394070
V3	0.1008388327	0.1840066816	0.0849216522	0.0602963069	0.0364372376
V4	0.0696239785	0.0849216522	0.1450543396	0.0468940649	0.0177807609
V5	0.0359024228	0.0602963069	0.0468940649	0.2507806084	0.0569701760
V6	0.0211394070	0.0364372376	0.0177807609	0.0569701760	0.1450543396
V8	0.0384819157	0.0524272846	0.0146762180	0.0550614306	0.0449809421
V11	0.0270892346	-.0089083928	-.0116108472	0.0208091369	0.0186928792
V12	0.0144942371	0.0165958942	0.0202398737	0.0679570598	0.0263222492
V13	0.0120839675	-.0090538542	-.0017157161	0.0196861586	0.0043449770
V15	-.0223793336	0.0011692141	0.0026644777	0.0374973398	0.0329680095

Covariances

	V8	V11	V12	V13	V15
V1	0.0384819157	0.0270892346	0.0144942371	0.0120839675	-.0223793336
V3	0.0524272846	-.0089083928	0.0165958942	-.0090538542	0.0011692141
V4	0.0146762180	-.0116108472	0.0202398737	-.0017157161	0.0026644777
V5	0.0550614306	0.0208091369	0.0679570598	0.0196861586	0.0374973398
V6	0.0449809421	0.0186928792	0.0263222492	0.0043449770	0.0329680095
V8	0.2470984681	0.0457841044	0.0591594194	0.0346109332	0.0166473979
V11	0.0457841044	0.2164296484	0.0709465489	0.0457103169	0.0324197561
V12	0.0591594194	0.0709465489	0.1716196329	0.0554070429	0.0395110413
V13	0.0346109332	0.0457103169	0.0554070429	0.1370184256	0.0301203195
V15	0.0166473979	0.0324197561	0.0395110413	0.0301203195	0.3668846041

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Determinant 1.5879961E-8 Ln -17.958208

NOTE: Some initial estimates computed by instrumental variable method.

NOTE: Some initial estimates computed by two-stage LS method.

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Vector of Initial Estimates

	Parameter	Estimate	Type
1	LV6F2	0.55428	Matrix Entry: _BETA_[5:12]
2	LV8F2	0.76552	Matrix Entry: _BETA_[6:12]
3	LV1F3	0.80315	Matrix Entry: _GAMMA_[1:1]
4	LV4F3	0.61319	Matrix Entry: _GAMMA_[3:1]
5	LV11F4	0.58322	Matrix Entry: _GAMMA_[7:2]
6	LV13F4	0.42347	Matrix Entry: _GAMMA_[9:2]
7	PF1F4	0.35715	Matrix Entry: _GAMMA_[11:2]

8	PF2F3	0.39366	Matrix Entry: _GAMMA_[12:1]
9	PF2F4	0.45289	Matrix Entry: _GAMMA_[12:2]
10	VARF3	0.13244	Matrix Entry: _PHI_[1:1]
11	VARF4	0.13115	Matrix Entry: _PHI_[2:2]
12	VARE1	0.10767	Matrix Entry: _PHI_[3:3]
13	VARE3	0.05157	Matrix Entry: _PHI_[4:4]
14	VARE4	0.09526	Matrix Entry: _PHI_[5:5]
15	VARE5	0.16430	Matrix Entry: _PHI_[6:6]
16	VARE6	0.11849	Matrix Entry: _PHI_[7:7]
17	VARE8	0.19642	Matrix Entry: _PHI_[8:8]
18	VARE11	0.17182	Matrix Entry: _PHI_[9:9]
19	VARE12	0.04047	Matrix Entry: _PHI_[10:10]
20	VARE13	0.11350	Matrix Entry: _PHI_[11:11]
21	VARD1	0.35016	Matrix Entry: _PHI_[12:12]
22	VARD2	0.03396	Matrix Entry: _PHI_[13:13]

Predetermined Elements of the Predicted Moment Matrix

	V1	V3	V4	V5	V6
V1	.	.	.	.	.
V3	.	.	.	.	.
V4	.	.	.	.	.
V5	.	.	.	.	.
V6	.	.	.	.	.
V8	.	.	.	.	.
V11	0	0	0	.	.
V12	0	0	0	.	.
V13	0	0	0	.	.
V15	0	0	0	.	.

Predetermined Elements of the Predicted Moment Matrix

	V8	V11	V12	V13	V15
V1	.	0	0	0	0
V3	.	0	0	0	0
V4	.	0	0	0	0
V5	.	.	.	.	.
V6	.	.	.	.	.
V8	.	.	.	.	.
V11	.	.	.	.	.
V12	.	.	.	.	.
V13	.	.	.	.	.
V15	.	.	.	.	.

WARNING: The predicted moment matrix has 12 constant elements whose values differ from those of
the observed moment matrix. The sum of squared differences is 0.0025833963.

NOTE: Only 43 elements of the moment matrix are used in the model specification.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation
Levenberg-Marquardt Optimization
Scaling Update of More (1978)
Parameter Estimates 22
Functions (Observations) 55

Optimization Start

Active Constraints	0	Objective Function	0.2276614427
Max Abs Gradient Element	0.5340260986	Radius	6.535033911

Iter	Restarts	Function Calls	Active Constraints	Objective Function	Max Abs Objective Function Change	Max Abs Gradient Element	Ratio Between Actual and Predicted Lambda Change
1	0	2	0	0.21227	0.0154	0.2587	0 0.919
2	0	3	0	0.21012	0.00215	0.0286	0 0.970
3	0	4	0	0.21006	0.000059	0.00593	0 0.944
4	0	5	0	0.21006	4.312E-6	0.00159	0 0.975
5	0	6	0	0.21006	3.492E-7	0.000879	0 0.979
6	0	7	0	0.21006	3.139E-8	0.000154	0 0.944
7	0	8	0	0.21006	3.152E-9	0.000122	0 0.873
8	0	9	0	0.21006	3.55E-10	0.000024	0 0.791

Optimization Results

Iterations	8	Function Calls	10
Jacobian Calls	9	Active Constraints	0
Objective Function	0.2100554043	Max Abs Gradient Element	0.0000237949
Lambda	0	Actual Over Pred Change	0.7914788852
Radius	0.0000982868		

GCONV convergence criterion satisfied.

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Predicted Model Matrix

	V1	V3	V4	V5	V6
V1	0.1930987249	0.1015934832	0.0632325175	0.0400940755	0.0234284136
V3	0.1015934832	0.1840066816	0.0860478559	0.0545606812	0.0318817728
V4	0.0632325175	0.0860478559	0.1450543396	0.0339589620	0.0198434456
V5	0.0400940755	0.0545606812	0.0339589620	0.2482170169	0.0451896415
V6	0.0234284136	0.0318817728	0.0198434456	0.0451896415	0.1441790803
V8	0.0349366618	0.0475423873	0.0295907252	0.0673872012	0.0393767708
V11	0.0000000000	0.0000000000	0.0000000000	0.0389213119	0.0227431255
V12	0.0000000000	0.0000000000	0.0000000000	0.0542635107	0.0317081253
V13	0.0000000000	0.0000000000	0.0000000000	0.0302785006	0.0176928194
V15	0.0000000000	0.0000000000	0.0000000000	0.0248017189	0.0144925384

Predicted Model Matrix

	V8	V11	V12	V13	V15
V1	0.0349366618	0.0000000000	0.0000000000	0.0000000000	0.0000000000
V3	0.0475423873	0.0000000000	0.0000000000	0.0000000000	0.0000000000
V4	0.0295907252	0.0000000000	0.0000000000	0.0000000000	0.0000000000
V5	0.0673872012	0.0389213119	0.0542635107	0.0302785006	0.0248017189
V6	0.0393767708	0.0227431255	0.0317081253	0.0176928194	0.0144925384
V8	0.2451520476	0.0339147540	0.0472834426	0.0263836919	0.0216114040
V11	0.0339147540	0.2164296484	0.0715256071	0.0399105792	0.0326915450

V12	0.0472834426	0.0715256071	0.1716196329	0.0556427324	0.0455780630
V13	0.0263836919	0.0399105792	0.0556427324	0.1370184256	0.0254321070
V15	0.0216114040	0.0326915450	0.0455780630	0.0254321070	0.3668846041

Determinant 1.9591845E-8 Ln -17.748152

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Function	0.2101
Goodness of Fit Index (GFI)	0.9590
GFI Adjusted for Degrees of Freedom (AGFI)	0.9317
Root Mean Square Residual (RMR)	0.0098
Parsimonious GFI (Mulaik, 1989)	0.7033
Chi-Square	34.4491
Chi-Square DF	33
Pr > Chi-Square	0.3983
Independence Model Chi-Square	278.00
Independence Model Chi-Square DF	45
RMSEA Estimate	0.0164
RMSEA 90% Lower Confidence Limit	.
RMSEA 90% Upper Confidence Limit	0.0603
ECVI Estimate	0.4976
ECVI 90% Lower Confidence Limit	.
ECVI 90% Upper Confidence Limit	0.6112
Probability of Close Fit	0.8711
Bentler's Comparative Fit Index	0.9938
Normal Theory Reweighted LS Chi-Square	35.0319
Akaike's Information Criterion	-31.5509
Bozdogan's (1987) CAIC	-167.0471
Schwarz's Bayesian Criterion	-134.0471
McDonald's (1989) Centrality	0.9956
Bentler & Bonett's (1980) Non-normed Index	0.9915
Bentler & Bonett's (1980) NFI	0.8761
James, Mulaik, & Brett (1982) Parsimonious NFI	0.6425
Z-Test of Wilson & Hilferty (1931)	0.2579
Bollen (1986) Normed Index Rho1	0.8310
Bollen (1988) Non-normed Index Delta2	0.9941
Hoelter's (1983) Critical N	227

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Raw Residual Matrix

	V1	V3	V4	V5	V6
V1	0.0000000000	-.0007546505	0.0063914609	-.0041916527	-.0022890066
V3	-.0007546505	0.0000000000	-.0011262037	0.0057356257	0.0045554647
V4	0.0063914609	-.0011262037	0.0000000000	0.0129351029	-.0020626847
V5	-.0041916527	0.0057356257	0.0129351029	0.0025635915	0.0117805345
V6	-.0022890066	0.0045554647	-.0020626847	0.0117805345	0.0008752593
V8	0.0035452539	0.0048848973	-.0149145072	-.0123257706	0.0056041713
V11	0.0270892346	-.0089083928	-.0116108472	-.0181121750	-.0040502463
V12	0.0144942371	0.0165958942	0.0202398737	0.0136935492	-.0053858761
V13	0.0120839675	-.0090538542	-.0017157161	-.0105923421	-.0133478424
V15	-.0223793336	0.0011692141	0.0026644777	0.0126956209	0.0184754711

Raw Residual Matrix

	V8	V11	V12	V13	V15
V1	0.0035452539	0.0270892346	0.0144942371	0.0120839675	-.0223793336
V3	0.0048848973	-.0089083928	0.0165958942	-.0090538542	0.0011692141
V4	-.0149145072	-.0116108472	0.0202398737	-.0017157161	0.0026644777
V5	-.0123257706	-.0181121750	0.0136935492	-.0105923421	0.0126956209
V6	0.0056041713	-.0040502463	-.0053858761	-.0133478424	0.0184754711
V8	0.0019464205	0.0118693504	0.0118759767	0.0082272412	-.0049640061
V11	0.0118693504	0.0000000000	-.0005790582	0.0057997377	-.0002717889
V12	0.0118759767	-.0005790582	0.0000000000	-.0002356895	-.0060670217
V13	0.0082272412	0.0057997377	-.0002356895	0.0000000000	0.0046882125
V15	-.0049640061	-.0002717889	-.0060670217	0.0046882125	0.0000000000

Average Absolute Residual 0.007226

Average Off-diagonal Absolute Residual 0.008712

Rank Order of the 10 Largest Raw Residuals

Row	Column	Residual
V11	V1	0.02709
V15	V1	-0.02238
V12	V4	0.02024
V15	V6	0.01848
V11	V5	-0.01811
V12	V3	0.01660
V8	V4	-0.01491
V12	V1	0.01449
V12	V5	0.01369
V13	V6	-0.01335

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Asymptotically Standardized Residual Matrix

	V1	V3	V4	V5	V6
V1	0.000000000	-0.641617970	1.439716136	-0.323104014	-0.213459257
V3	-0.641617970	0.000000000	-1.026951440	0.598368417	0.526011334
V4	1.439716136	-1.026951440	0.000000000	1.135579250	-0.219963066
V5	-0.323104014	0.598368417	1.135579250	0.882740585	1.485678365
V6	-0.213459257	0.526011334	-0.219963066	1.485678365	0.882664477
V8	0.262733527	0.465105303	-1.261760584	-1.400212129	0.606446055
V11	1.696955985	-0.571670932	-0.839193463	-1.315602635	-0.353314866
V12	1.019633504	1.195975545	1.642785554	1.508094735	-0.655338487
V13	0.951376199	-0.730212288	-0.155852044	-0.957243532	-1.453257285
V15	-1.076749372	0.057628118	0.147912170	0.613297544	1.115137101

Asymptotically Standardized Residual Matrix

	V8	V11	V12	V13	V15
V1	0.262733527	1.696955985	1.019633504	0.951376199	-1.076749372
V3	0.465105303	-0.571670932	1.195975545	-0.730212288	0.057628118
V4	-1.261760584	-0.839193463	1.642785554	-0.155852044	0.147912170
V5	-1.400212129	-1.315602635	1.508094735	-0.957243532	0.613297544
V6	0.606446055	-0.353314866	-0.655338487	-1.453257285	1.115137101
V8	0.882711000	0.825004624	1.192891255	0.712779343	-0.234681791
V11	0.825004624	0.000000000	-0.186883681	0.744098441	-0.016173514
V12	1.192891255	-0.186883681	0.000000000	-0.091792531	-0.850094854
V13	0.712779343	0.744098441	-0.091792531	0.000000000	0.346170981
V15	-0.234681791	-0.016173514	-0.850094854	0.346170981	0.000000000

Average Standardized Residual 0.682048

Average Off-diagonal Standardized Residual 0.774767

Rank Order of the 10 Largest Asymptotically Standardized Residuals

Row	Column	Residual
V11	V1	1.69696
V12	V4	1.64279
V12	V5	1.50809
V6	V5	1.48568
V13	V6	-1.45326
V4	V1	1.43972
V8	V5	-1.40021
V11	V5	-1.31560
V8	V4	-1.26176
V12	V3	1.19598

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Distribution of Asymptotically Standardized Residuals

Each * Represents 1 Residuals

----------Range---------		Freq	Percent	
-1.50000	-1.25000	4	7.27	****
-1.25000	-1.00000	2	3.64	**
-1.00000	-0.75000	3	5.45	***
-0.75000	-0.50000	4	7.27	****
-0.50000	-0.25000	2	3.64	**
-0.25000	0	7	12.73	*******
0	0.25000	9	16.36	*********
0.25000	0.50000	3	5.45	***
0.50000	0.75000	6	10.91	******
0.75000	1.00000	5	9.09	*****
1.00000	1.25000	5	9.09	*****
1.25000	1.50000	2	3.64	**
1.50000	1.75000	3	5.45	***

Manifest Variable Equations with Estimates

V1 = 0.7349*F3 + 1.0000 E1
Std Err 0.1174 LV1F3
t Value 6.2606
V3 = 1.0000 F3 + 1.0000 E3
V4 = 0.6224*F3 + 1.0000 E4
Std Err 0.1007 LV4F3
t Value 6.1807
V5 = 1.0000 F2 + 1.0000 E5
V6 = 0.5843*F2 + 1.0000 E6
Std Err 0.1572 LV6F2
t Value 3.7180
V8 = 0.8714*F2 + 1.0000 E8
Std Err 0.2153 LV8F2
t Value 4.0472
V11 = 0.7173*F4 + 1.0000 E11
Std Err 0.1710 LV11F4
t Value 4.1935
V12 = 1.0000 F4 + 1.0000 E12
V13 = 0.5580*F4 + 1.0000 E13
Std Err 0.1347 LV13F4
t Value 4.1440
V15 = 1.0000 F1

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Latent Variable Equations with Estimates

F1	=	0.4571*F4	+	1.0000 D1	
Std Err		0.1885 PF1F4			
t Value		2.4247			
F2	=	0.3947*F3	+	0.5442*F4	+ 1.0000 D2
Std Err		0.1006 PF2F3		0.1478 PF2F4	
t Value		3.9223		3.6810	

Variances of Exogenous Variables

Variable	Parameter	Standard Estimate	Error	t Value
F3	VARF3	0.13825	0.02635	5.25
F4	VARF4	0.09972	0.02609	3.82
E1	VARE1	0.11844	0.01643	7.21
E3	VARE3	0.04576	0.01823	2.51
E4	VARE4	0.09150	0.01240	7.38
E5	VARE5	0.17088	0.02578	6.63
E6	VARE6	0.11777	0.01484	7.94
E8	VARE8	0.18643	0.02505	7.44
E11	VARE11	0.16513	0.02164	7.63
E12	VARE12	0.07190	0.02115	3.40
E13	VARE13	0.10597	0.01372	7.73
D1	VARD1	0.34605	0.03926	8.81
D2	VARD2	0.02627	0.01706	1.54

Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Standardized Estimates

V1	=	0.6218*F3	+	0.7832 E1
		LV1F3		
V3	=	0.8668 F3	+	0.4987 E3
V4	=	0.6076*F3	+	0.7942 E4
		LV4F3		
V5	=	0.5582 F2	+	0.8297 E5
V6	=	0.4280*F2	+	0.9038 E6
		LV6F2		
V8	=	0.4894*F2	+	0.8721 E8
		LV8F2		
V11	=	0.4869*F4	+	0.8735 E11
		LV11F4		
V12	=	0.7623 F4	+	0.6473 E12
V13	=	0.4760*F4	+	0.8794 E13
		LV13F4		
V15	=	1.0000 F1		

The CALIS Procedure

Covariance Structure Analysis: Maximum Likelihood Estimation

Latent Variable Equations with Standardized Estimates

F1	=	0.2383*F4	+	0.9712 D1		
		PF1F4				
F2	=	0.5277*F3	+	0.6179*F4	+	0.5829 D2
		PF2F3		PF2F4		

Squared Multiple Correlations

	Variable	Error Variance	Total Variance	R-Square
1	V1	0.11844	0.19310	0.3866
2	V3	0.04576	0.18401	0.7513
3	V4	0.09150	0.14505	0.3692
4	V5	0.17088	0.24822	0.3116
5	V6	0.11777	0.14418	0.1831
6	V8	0.18643	0.24515	0.2395
7	V11	0.16513	0.21643	0.2370
8	V12	0.07190	0.17162	0.5811
9	V13	0.10597	0.13702	0.2266
10	V15	.	0.36688	.
11	F1	0.34605	0.36688	0.0568
12	F2	0.02627	0.07734	0.6603

Stepwise Multivariate Wald Test

	------Cumulative Statistics-----			--Univariate Increment--	
Parameter	Chi-Square	DF	Pr > ChiSq	Chi-Square	Pr > ChiSq
VARD2	2.37065	1	0.1236	2.37065	0.1236

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