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A Measurement Model of Child Health: Latent Variables Approach

Shafqat Shehzad PhD

Abstract

The paper addresses the controversial issue of health measurement using latent variables. Following issues are explored (i) child health is unobservable but can be represented by observed health indicators (ii) different indicators represent different underlying health states (iii) permanent health has a positive impact on transitory health deviations. The results show that empirically there is a distinction between child health states: permanent and transitory. Child's permanent health has a positive impact on transitory health deviations.

Key words: Health measurement, latent variables, permanent and transitory health.

JEL Classification: 110

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1. Introduction and Statement of the Problem

Theoretical and empirical work relating to child health identifies various problems in health measurement that broadly include (i) unobservability of health status (ii) problem of differentiating between different health states and (iii) if health is measured through various indicators then the problem of measuring these inherently imperfect health indicators. Behrman and Deolalikar (1988, pp. 650) examine that "problems relating to health measurement are manifold and often result in certain controversies and ambiguities in the literature". Grossman (1972, pp. 45) presents a model of health determination in which health is seen as a durable capital stock that depreciates overtime. However, Grossman also shows that "the stock of health... is a theoretical concept, one that is difficult to quantify empirically". On the other hand, healthy time output and flow of services yielded by health capital can be measured easily. Studies by Behrman and Wolfe (1987), Van Doorslaer (1987), and Wagstaff (1993). Identify problems of unobservability and suggest ways to solve them. The studies suggest using latent variables to overcome unobservability and employ micro-representations of health status. Behrman and Deolalikar (1988) argue that due to the imperfect nature of indicators, a number of indicators should be used to illustrate health. Van Doorslaer (1987) tried to distinguish between Grossman's stocks and flow concepts of health at the empirical level. However, his results relating to transitory health were peculiar: the coefficients of determinants were mostly of the opposite signs casting doubt on the relationship between different health states. Empirical research relating to health measurement has therefore, been constrained by the issue of unobservability of health status and appropriate estimation techniques. This study addresses the complex issue of child health measurement and uses latent variables to overcome health unobservability. To take care of the imperfect nature of health indicators, a standardised reference has been used for multiple health indicators. The following issues specific have been addressed:

- Child health is unobservable but can be represented by several observed health indicators.
- Different observed health indicators represent different underlying health states.
- Child's permanent health state has a positive influence on transitory health deviations.
- Different morbidity related indicators represent the same underlying theoretical value.

2. Data & Definition of Variables: Health Status of Children in Pakistan

The study uses the only available micro level data, Pakistan Demographic and Health survey (PDHS, 1990-91) for measuring child health. To estimate and distinguish between different health states, a number of anthropometric and morbidity related indicators have been used. Child's transitory health deviation are represented by (i) prevalence of fever as a sign of malaria or other illness (ii) cough accompanied by rapid breathing e.g. acute respiratory infections or ARIs and (iii) diarrhea among children for the past two weeks preceding the survey interview. Child's permanent health is indicated by standardized anthropometric indicators as (i) height for age (ii) weight for age and (iii) arm circumference. Based on the

recommendations of the World Health Organization (1976, 1983), this study calculates Z-scores for height and weight for age for children in Pakistan. The following formula as defined by Waterlow et al (1977) has been used to standardize permanent health indicators.

$$Z\text{-Score} = \frac{\text{Individual anthropometric value} - \text{Median of reference population}}{\text{SD of reference population}}$$

The calculation of Z- scores provides standardized values for height and weight for age. Arm circumference has been standardized as described in table 1. To carry out estimations in LISREL 8.0, Joreskog and Sorbom (1993) show how to deal with data that are categorical in nature. They recommend that LISREL models having two or more observed categorical variables, polychoric correlation should be calculated. Polychoric correlation estimated by maximum likelihood method assumes that each variable corresponds to a latent variable with a continuous distribution. New threshold values are calculated on the assumption that the joint distribution between the pairs of latent variables is normal. To develop measurement models for child health, data have initially been prepared in SPSS for use in PRELIS, (Joreskog and Sorbom, 1993). As variables used in the measurement models are of mixed scale types, estimates of polychoric correlation have been computed in PRELIS. Variables have been transformed to obtain asymptotic (large sample) covariance matrix for use in LISREL.

Table-1 Classification of arm circumference

Categories	Arm Circumference in cm	Arm Circumference for height (% of reference standard)	Arm Circumference for Weight (% of reference standard)*
Well nourished and mild PEM	13.5 or more	85% or more	80% or more
Moderate PEM	12.5-13.5	70-85%	70-80%
Severe PEM	under 12.5	Under 70%	Under 70%

Source: Ville de Goyet et al (1978p. 30). *Note: Equivalent SD (Z-score) values are 80%, minus 2 SD; 70%, minus 3 SD. a: Protein Energy Malnutrition or PEM.

Table- 2 Description of variables in child health measurement models

Variables	Description	Mean	SD	Skewness
<u>Permanent health indicator</u>				
Standardized weight	Value for a child in the sample minus the international standards for a child of the same age and gender relative to the SD in the international standards for weight.	-1.90	1.50	1.719
Standardized height	Value for a child in the sample minus the international standards for a child of the same age and gender relative to the SD in the international standards for height.	-2.82	2.172	-0.350
Standardized arm circumference	Standardized arm circumference in cm. see table 1.1 for categories.	2.582	0.723	-0.139
<u>Transitory health indicators</u>				
Fever	Child had fever in the last two weeks	0.30	0.458	0.873
Cough/respiratory infection	Child had cough in the last two weeks	0.335	0.472	0.699
Diarrhea	Child had diarrhea in the last two weeks	0.145	0.352	2.018

Source: PDHS.1990-91

3. LISREL Notation Used in the Child Health Measurement Model

The following notation has been used in the child health measurement model. For reference, see LISREL: A Guide to the Program and Applications.

y = Observed variables

$LY = \Lambda y = \lambda$ = Factor loading

η = Latent variables

ε = Error variables in the regression equation (errors of measurement)

ζ = Vector of residuals: errors in equation, random disturbance term (error variables relating to latent variables).

$PSI = \Psi$ = Covariance matrix

$TE = \theta\varepsilon$ = Error covariance matrix

NE = Number of η variables

Other terms used: for definitions and description, see text in the next section

SMC = Squared Multiple Correlations

RMR = Root Mean Squared Residuals

GFI = Goodness of Fit Index

AGFI = Adjusted Goodness of Fit Index

PH = Permanent health state

TH = Transitory health state

df = degrees of freedom
ML = Maximum Likelihood Method
GLS = Generalized Least Squares Method
S and Σ = sample covariance and model based covariance matrix

Table- 3 LISREL Notation for number of variables

	Mathematical notation	LISREL Notation
Number of Y variables	p	NY
Number of η variables	m	NE

Source: LISREL Program: User's Manual and Reference Guide.

4. Method of Analysis

To measure child health, MIMIC models have been estimated in LISREL 8.0. The LISREL model consists of two parts, (i) measurement model and the (ii) structural equation model. For analysis, unobserved child health is related to observed health indicators in a system of equations. The model describes how well the observable indicators serve as measurement instruments for the unobservable child health. In absence of any explanatory variables, the structural part of the LISREL model can be written as

$$\eta = \zeta \quad \text{And} \quad \zeta \sim N(0, \Psi)$$

$\eta = \mathbf{m} \times \mathbf{1}$ vector of endogenous latent variables
 $\zeta = \mathbf{m} \times \mathbf{1}$ vector of disturbance terms
 $\Psi = \mathbf{m} \times \mathbf{m}$ covariance matrix of ζ

The measurement model is described by an equation that specifies the relations between unobserved health but observed child health indicators. LISREL formulation assumes that all of these variables are expressed in deviation form. For latent variables, the following equation is specified $y = \Lambda_y \eta + \varepsilon$. For one latent variable η , the measurement model as formulated in LISREL is presented below

LISREL Model 1 One Latent Variable Case

A. Measurement Model

$$y = \Lambda_y \eta + \varepsilon \quad \varepsilon \sim N(0, \theta_\varepsilon)$$

$(6 \times 1)(6 \times 1) (6 \times 1)$

Assumptions:

$$E(y) = E(\zeta) = E(\eta) = E(\varepsilon) = 0$$

$$E(\varepsilon, \eta) = 0$$

$$E(\zeta, \varepsilon) = 0$$

In empirical analysis, there is an important caveat in measuring health with the help of several indicators. The use of simple regression analysis does not allow to distinguish between stocks and flow concepts of health; as conceived by Grossman (1972). However, use of latent variables enables us to distinguish between different health states, see for example Van Doorslaer (1987). To estimate the relationship between underlying stocks and flow concepts of health, child's health states have been named as permanent and transitory. Table 2 describes multiple indicators used to represent these states. By introducing transitory health variables in the measurement model, two latent variables models can be estimated in LISREL. As long as there are no explanatory variables in the model, the structural equation remains unchanged.

LISREL Model II: Two Latent Variables Case

B. Measurement Model

$$y = \Lambda_y \eta + \varepsilon \quad \varepsilon \sim N(0, \theta_\varepsilon)$$

(6x1) (6x2) (2x1) (6x1)

Assumptions:

$$E(y) = E(\zeta) = E(\eta) = E(\varepsilon) = 0$$

$$E(\varepsilon, \eta) = 0$$

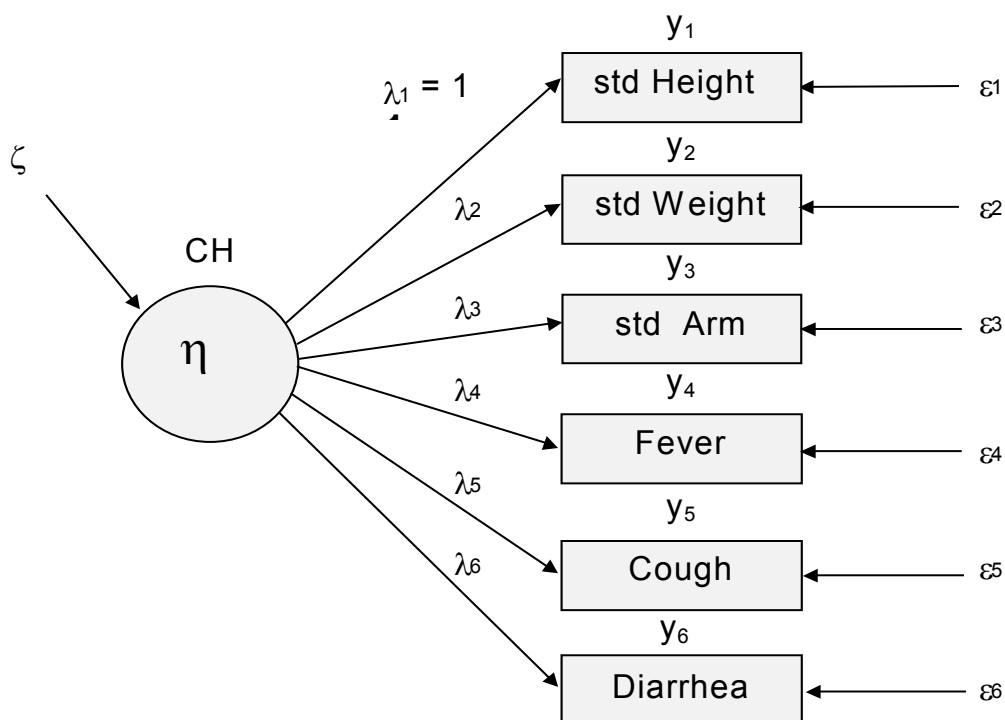
$$E(\zeta, \varepsilon) = 0$$

In figure 1, variable η is a theoretical variable (unobservable child health state) and y variables are fallible measures that are chosen to measure η (health indicators). The ε 's are random measurement errors in y variables. These variables are correlated because they are assumed to have an underlying unobserved factor η . If this is eliminated from the y variables, only pure random errors remain.

Figure 1. Measurement Model of Child Health

One Latent Variable Case

All six variables listed can be seen as indicators of one underlying latent variable, child health.



Model Equations

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \\ y_6 \end{bmatrix} = \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \\ \lambda_6 \end{bmatrix} \eta + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \end{bmatrix}$$

$$\begin{matrix} Y \\ (6 \times 1) \end{matrix} = \begin{matrix} \lambda \\ (6 \times 1) \end{matrix} \eta + \begin{matrix} \varepsilon \\ (6 \times 1) \end{matrix}$$

Joreskog and Sorbom (1989, pp. 4) examine that due to unobservability, the latent variable η does not have a definite scale. Therefore, the origin and unit of measurement in η cannot be defined. Two normalization procedures have been described by Joreskog and Sorbom (1989, pp. 4) in order to define the scale of latent variables. These are as follows:

- Fix one λ coefficient for each latent variable equal to a constant (e.g. 1). This will give latent variable the same unit of measurement as one of the indicators.
- Fix the variances of the unobserved variables equal to one. This will give the direct standardized solution to the problem.

Figure 2 shows that if all selected child health indicators belong to only one unobserved state of health, η , then the hypothesis can be tested by imposing a restriction on the covariance matrix that $\psi_{21} = 1$. When the covariance between the two latent constructs is put equal to one, this implies that both represent the same health state. Saris and Stronkhorst (1984, p. 276) show that this restriction can be checked by the looking at the difference in χ^2 statistic between the restricted and unrestricted model that itself has a χ^2 distribution with one degree of freedom. If the restriction is rejected, this means that the unobservable health can be divided into permanent and transitory health states. Therefore, child health measurement model as postulated in this section can be regarded as "the co generic measurement model" in LISREL terminology. The observed variables are denoted by y_i and the latent variable is denoted by η . The measurement errors in y are denoted by ϵ_i . Joreskog and Sorbom (1989, pp. 77-79) explain that a co generic model implies that "if the latent variable were observed", it would produce values of observed variables y_i ." The coefficients λ_i associated with arrows from η represent regression coefficients in the relationship between y_i and η . Using another terminology for the same model, we can say that the partial correlation between any pair of variables y_i and y_j given η is zero.

Therefore, in this sense η is assumed to account for all the Interco relations among y 's. Thus, in a co generic measurement model, measures $y_1, y_2, y_3, y_4, y_5, y_6$ are co generic if their true values $\tau_1, \tau_2, \tau_3, \tau_4, \tau_5, \tau_6$ are such that every pair of τ_i, τ_j have a unit correlation. The true values are $\tau_i = \lambda_i \eta = y_i - \epsilon_i$. To explore the hypothesis that certain indicators are co generic (measure the same theoretical value) or parallel (have identical true and error variances), LISREL Program provides two types of model modifications based on modification indices. These are (1) indicator loading on latent variables and (2) correlations between the disturbances of the measurement equation. The estimation requires that zero covariance restriction on the disturbance terms is relaxed and error terms are allowed to co vary. Empirical evidence suggests that children suffering from fever may also experience cough or respiratory problems. Thus, it is expected that the error terms of fever and cough /respiratory infection co vary. To test the hypothesis that fever and cough represent the same deteriorated underlying health state, another restriction on the model is imposed, that is $\lambda_{4,2} = \lambda_{5,2}$. This is shown in figure 3. The equality of these two estimates can be tested by using the difference in χ^2 test statistic. If the restriction holds, this implies that indicators are taken to be co generic instruments. The additional restriction is that these indicators have equal variances, $H_0: \theta_{\epsilon 4,4} = \theta_{\epsilon 5,5}$. If this restriction holds then the instruments are regarded as parallel instruments. The results are given in tables 5 & 6.

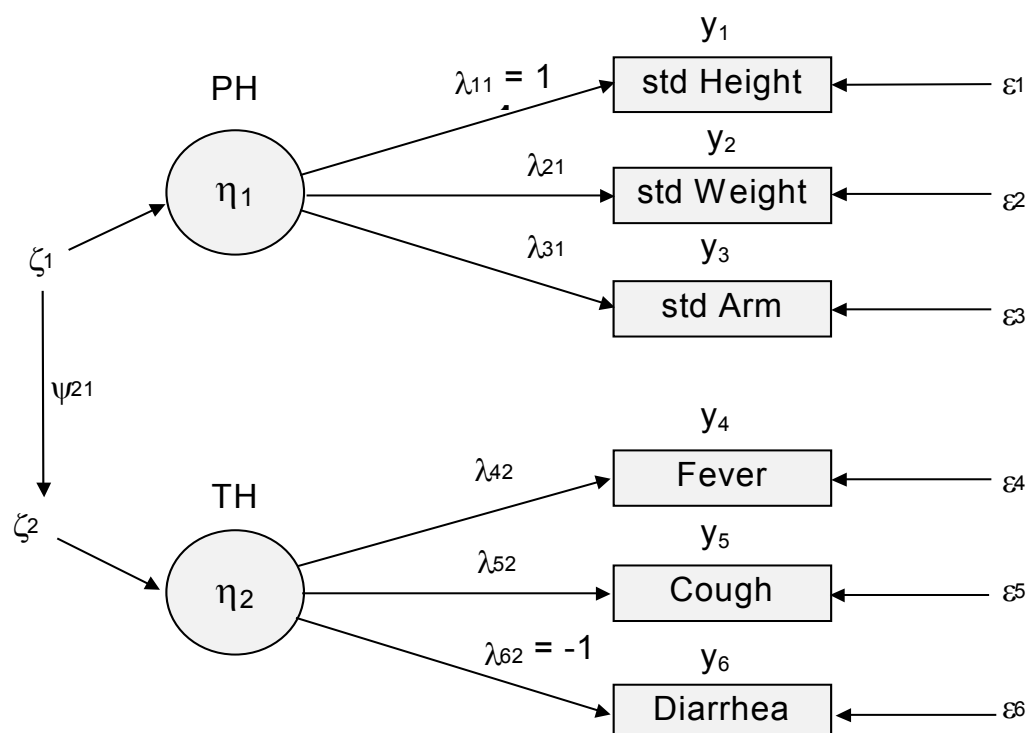
Figure 2. Measurement Model of Child Health

Two Latent Variables Case

Null hypothesis is that all indicators reflect child health by testing $H_0: \psi_{21} = 1$

H_1 : Child health can be divided into permanent and transitory health states.

PH = Permanent Health, TH = Transitory Health



Model Equation:

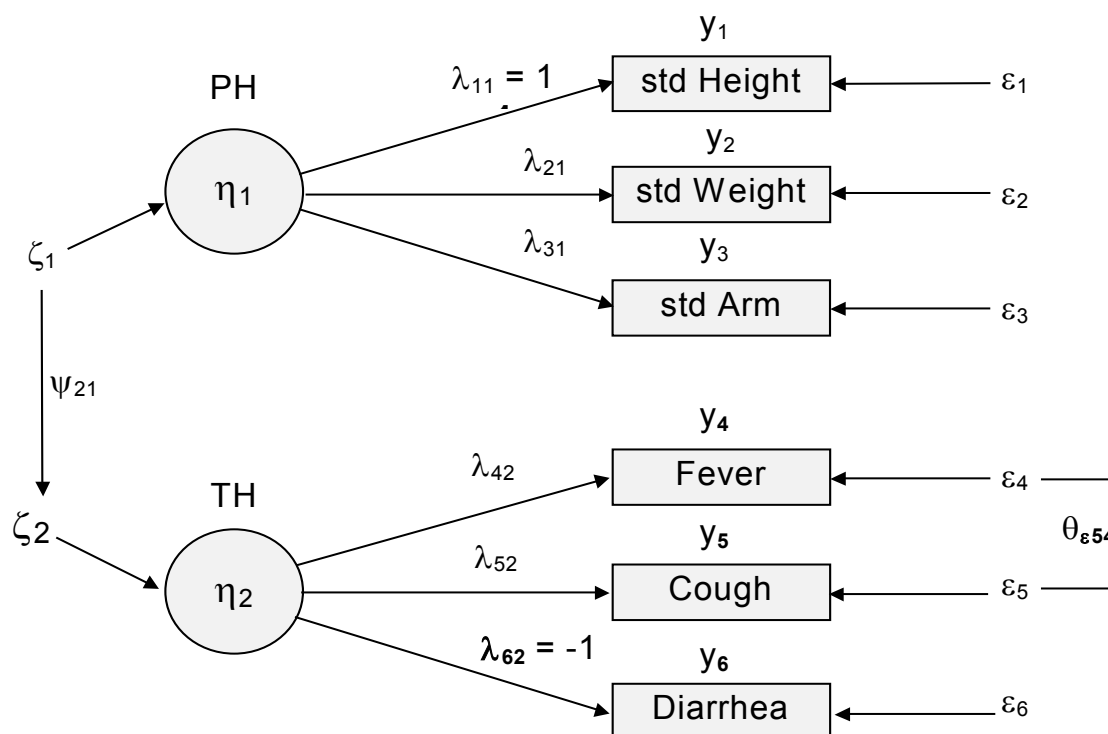
$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \\ y_6 \end{bmatrix} = \begin{bmatrix} \lambda_{11} & 0 \\ \lambda_{21} & 0 \\ \lambda_{31} & 0 \\ 0 & \lambda_{42} \\ 0 & \lambda_{52} \\ 0 & \lambda_{62} \end{bmatrix} \begin{bmatrix} \eta_1 \\ \eta_2 \end{bmatrix} + \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \\ \epsilon_3 \\ \epsilon_4 \\ \epsilon_5 \\ \epsilon_6 \end{bmatrix}$$

$$\mathbf{Y} = \boldsymbol{\lambda} \boldsymbol{\eta} + \boldsymbol{\epsilon}$$

(6 x 1) (6 x 2) (2 x 1) (6 x 1)

Figure 3. Measurement Model of Child Health

Two Latent Variables Case



PH = Permanent Health, TH = Temporary Health

Model Equation:

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \\ y_6 \end{bmatrix} = \begin{bmatrix} \lambda_{11} & 0 \\ \lambda_{21} & 0 \\ \lambda_{31} & 0 \\ 0 & \lambda_{42} \\ 0 & \lambda_{52} \\ 0 & \lambda_{62} \end{bmatrix} \begin{bmatrix} \eta_1 \\ \eta_2 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \end{bmatrix}$$

$$\mathbf{Y} = \boldsymbol{\lambda} \boldsymbol{\eta} + \boldsymbol{\varepsilon}$$

(6×1) (6×2) (2×1) (6×1)

Restrictions $\lambda_{42} = \lambda_{52}$, $\theta_{\varepsilon 44} = \theta_{\varepsilon 55}$

(144). However, care must be taken while interpreting the value of chi-squared because Bentler and Bonett (1980) show that in case of non-nested model comparisons (one versus two latent variable models) tables 4 and 5 respectively, chi-squared test cannot be used. Therefore, instead of regarding χ^2 as test statistic, it is interpreted as goodness of fit measure and a small χ^2 represents a good model fit. The value of AGFI (0.97) shows that the model accounts very well for variances and covariances among the observed variables. The value of RMR is low (0.043). All other parameter estimates have the expected right signs and their effects are significant at 99 % level. The PSI matrix has all the positive and significant values. The strength of linear relationship as represented by SMC has greatly improved in table 5 for transitory health indicators as compared to their previous values. However, results in table 5 indicate two sources of problems. These are (i) negative value of error variance (TE) and (ii) greater than one value for SMC for standardized weight for age. These problems, however, disappear when more restrictions are added in the model. The findings however, urge the need to explore another closely related hypothesis: permanent and transitory health distortions represent the same underlying child health. If untrue, the results confirm that multiple indicators do not belong to a single underlying health state. A distinction between health states justifies the use of two latent variables each representing a different health state.

**Table- 4 LISREL estimates of health measurement model, International Standard:
One latent variable case***

Indicators	Child Health	TE	SMC
Standardized height	1.00a	0.66*** (31.57)	0.34
Standardized weight	1.48*** (20.87)	0.25*** (7.59)	0.75
St. Arm circumference	0.65*** (20.12)	0.86*** (42.84)	0.14
Fever	-0.31*** (10.36)	0.97*** (45.36)	0.03
Cough	-0.25*** (8.17)	0.98*** (45.55)	0.02
Diarrhea	-0.40*** (13.13)	0.94*** (44.99)	0.06
System estimates			
χ^2		6142 df = 9	
RMR		0.22	
AGFI		0.39	
PSI 1		0.34** (15.35)	

a: Normalised to be equal to 1 . Note: Values in the parentheses are t values, *** represents significant at 99% level, ** significant at 95 % and * at 90% level. When no t value is reported, this means that the parameter is equal to a fixed value. *Restriction: LY1=1

Table- 5 LISREL estimates (ML) of the health measurement model
International Standard: Two latent variables case*

Indicators	Permanent Health	Transitory Health	TE	SMC
Standardized height	1.00a		0.74*** (30.68)	0.26
Standardized weight	2.04*** (13.43)		-0.07 (0.95)	1.07
St. arm circumference	0.64*** (19.94)		0.89*** (42.90)	0.11
Fever		-2.20*** (27.78)	0.05*** (2.89)	0.95
Cough		-1.97*** (29.96)	0.24*** (16.08)	0.76
Diarrhea		-1.00b	0.80*** (44.83)	0.20
PSI matrix				
ψ_{11}			0.26*** (11.15)	
ψ_{22}			0.20*** (14.50)	
ψ_{21}			0.03*** (6.46)	
System estimates				
χ^2			144.25 df=8	
RMR			0.043	
AGFI			0.97	

a: Normalized to be equal to 1 . b: Normalized to be equal to minus 1. Note: Values in the parentheses are t values, *** represents significant at 99% level, ** significant at 95% and * at 90% level. When no t value is reported, this means that the parameter is equal to a fixed value.

*Restrictions: LY11= 1, LY62 = -1, NE= 2, PSI (2,1)

Table- 6 LISREL estimates (ML) of the health measurement model
International standard: Two latent variables case*

Indicators	Permanent Health	Transitory Health	TE	SMC
Standardized height	1.00a		0.53*** (22.23)	0.75
Standardized weight	0.86*** (58.88)		0.44*** (24.42)	0.73
St. arm circumference	0.41*** (31.46)		0.87*** (43.74)	0.24
Fever		-1.22*** (78.34)	0.11*** (11.85)	0.95
Cough		-1.15*** (75.80)	0.21*** (23.04)	0.89
Diarrhea		-1.00b	0.87*** (43.17)	0.60
PSI matrix				
ψ_{11}			1.62*** (44.79)	
ψ_{22}			1.28*** (43.47)	
ψ_{21}			1.00	
System estimates statistics				
χ^2	2964.23 df = 9			
RMR	0.86			
AGFI	0.65			

a: Normalized to be equal to 1 . b: Normalized to be equal to minus 1. Note: Values in the parentheses are t values, *** represents significant at 99% level, ** significant at 95 % and * at 90% level. When no t value is reported, this means that the parameter is equal to a fixed value. *Restrictions: LY11=1, LY62 = -1, NE= 2, PSI (2,1)=1

**Table- 7 LISREL estimates (ML) of the health measurement model
International Standard: Two latent variables case***

Indicators	Permanent health	Transitory health	TE	SMC
Standardized height	1.00a		0.72*** (31.59)	0.28
Standardized weight	1.88*** (15.58)		0.01 (0.17)	0.99
St. arm circumference	0.64*** (20.12)		0.88*** (43.20)	0.12
Fever		-0.65*** (8.02)	0.72*** (19.23)	0.28
Cough		-0.58*** (7.94)	0.78*** (23.99)	0.22
Diarrhea		-1.00b	0.33*** (4.07)	0.67
PSI matrix				
ψ_{11}			0.28*** (12.46)	
ψ_{22}			0.67*** (7.89)	
ψ_{21}			0.09*** (9.17)	
TE(5,4)			0.60*** (17.65)	
System estimates statistics				
χ^2			62.52 df=7	
RMR			0.025	
AGFI			0.99	

a: Normalized to be equal to 1 . b: Normalized to be equal to minus 1. Note: Values in the parentheses are t values, *** represents significant at 99% level, ** significant at 95 % and * at 90% level. When no t value is reported, this means that the parameter is equal to a fixed value. *Restrictions: LY11= 1, LY62 = -1, NE= 2, Free TE (5,4)

Table-8 LISREL Estimates (ML) of the health measurement model
International Standard: Two latent variables case*

Indicators	Permanent Health	Transitory Health	TE	SMC
Standardized height	1.00a		0.72*** (31.50)	0.28
Standardized weight	1.87*** (15.61)		0.01 (0.25)	0.99
St. arm circumference	0.64*** (20.13)		0.88*** (43.17)	0.12
Fever		-0.57*** (7.38)	0.75*** (21.33)	0.24
Cough		-0.57*** (7.38)	0.79*** (22.12)	0.23
Diarrhea		-1.00b	0.28*** (2.84)	0.72
PSI matrix				
ψ_{11}			0.28*** (12.48)	
ψ_{22}			0.72*** (7.31)	
ψ_{21}			0.09*** (9.19)	
System estimates				
χ^2			90.96 df=8	
RMR			0.026	
TE (5,4)			0.62*** (17.82)	
AGFI			0.98	

A: Normalised to be equal to 1. B: Normalised to be equal to minus 1. Note: Values in the parentheses are t values, *** represents significant at 99% level, ** significant at 95 % and * at 90% level. When no t value is reported, this means that the parameter is equal to a fixed value.

*Restrictions: LY11= 1, LY62 = -1, NE= 2,

Free TE (5,4) Equate LY (4,2) LY (5,2)

**Table- 9 LISREL estimates (ML) of the health measurement model
International Standard: Two latent variables case***

Indicators	Permanent Health	Transitory Health	TE	SMC
Standardized height	1.00a		0.72*** (31.48)	0.28
Standardized weight	1.87*** (15.62)		0.02 (0.28)	0.98
St. arm circumference	0.64*** (20.13)		0.88*** (43.17)	0.12
Fever		-0.55*** (7.20)	0.77*** (22.49)	0.23
Cough		-0.55*** (7.20)	0.77*** (22.38)	0.23
Diarrhea		-1.00b	0.26*** (2.57)	0.74
PSI matrix				
ψ_{11}			0.28*** (12.49)	
ψ_{22}			0.74*** (7.15)	
ψ_{21}			0.09*** (9.19)	
TE(5,4)			0.62*** (18.07)	
System estimates statistics				
χ^2	97.15 p=0.0 df = 9			
RMR	0.025			
AGFI	0.98			

a: Normalized to be equal to 1 . b: Normalized to be equal to minus 1. Note: Values in the parentheses are t values, *** represents significant at 99% level, ** significant at 95 % and * at 90% level. When no t value is reported, this means that the parameter is equal to a fixed value. *Restrictions: LY11=1, LY62 = -1, NE = 2, Equate LY (4,2) (5,2) Equate TE (4,4) (5,5)

To estimate a model having two latent variables, another restriction is imposed on the PSI matrix (covariance matrix) that $\text{PSI}(2,1) = 1$. The model is re-estimated with this added restriction to see if two latent variables represent one underlying health state. To test the hypothesis, the difference in chi-squared test as has been applied. A difference in the value of χ^2 of 2819.98 in table 6 leads us to reject the hypothesis that permanent and transitory states represent the same underlying theoretical value. This distinction between health states is retained in further analysis. The estimated values of AGFI fall and RMR rise in table 6, suggesting a not very good model fit. However, the value of TE for standardized weight is no more negative and its SMC is fairly high thus suggesting a better linear relationship.

In the health measurement model, another task is to inspect the modification indices of LISREL Program for possibility of correlated measurement errors of some health indicators. A review of modification indices shows that fever and cough turn out to be highly correlated. A high correlation between fever and cough implies that for a given level of transitory health, children who have cough are also expected to suffer from fever. Thus, another restriction is imposed in which TE (5,4) is set free meaning that the error variances of fever and cough are related. The results of this restriction in the model show an improvement in the overall goodness of fit and very good parameter estimates having right signs. Table 8 shows the results of hypothesis that fever and cough are co generic measures of child health. In terms of imposing restrictions in the model, this implies that LY (4,2) = LY (5,2). The equality of these two parameters can be tested by using the difference in χ^2 test statistic. Joreskog (1971) shows that χ^2 test statistic can be used as a measure of model comparison rather than evaluation of one model. The difference in chi-squared, therefore, can be written as $D = \chi^2(8) - \chi^2(7) = 90.96 - 62.52 = 28.44$. The difference in the value of chi-squared leads us to reject the hypothesis that both fever and cough are co generic measures (represent the same theoretical value). Thus, suggesting that although fever and cough are highly correlated, these two parameters are not co generic measures. The last restriction in the model tests whether the two transitory health indicators as fever and cough has equal variances. The hypothesis is that $H_0: TE(4,4) = TE(5,5)$. By using the difference in chi-squared, this restriction is also rejected, $D = \chi^2(9) - \chi^2(8) = 97.15 - 90.96 = 6.19$. The difference in the value of chi-squared shows that the restriction is rejected and fever and cough cannot be regarded as parallel instruments. Hence, measurement for the two health states cannot be done on the same scale.

6. Summary and Conclusions

This study deals with the measurement issues of child health. As health is inherently unobservable, research relating to health measurement is scant and previous attempts to explore relationship between different health states are unsatisfactory. The major reason for lack of empirical research relating to health measurement is that the standard regression analysis does not allow overcoming unobservability. Also, as suggested in the literature, a multiplicity of indicators needs to employ that may not represent the same underlying health state. Hence, a difference between health states urges the need to employ more than one latent variable.

The present study overcomes the problem of unobservability by employing latent variables. MIMIC models having one and two latent variables have been estimated. The use of multiple indicators helps to determine and differentiate between health states as permanent and transitory.

The results of study show that the underlying theoretical concepts of stock and flow concepts of health as presented by Grossman (1972) can successfully estimated and differentiated in a latent variables framework. LISREL formulation assumes latent child health variables are linked in a recursive manner: permanent health has a positive impact on transitory health deviations.

Children who have appropriate height for age, weight for age and arm circumference appear to be having a better permanent health state and overcome morbidity relatively more quickly than children who fall below the standard reference. It is therefore, incorrect to assume that child health can be represented by single underlying health state: different indicators represent different health states. However, as both health states are unobservable, a model having two latent variables is justified. Parental investment in child health therefore, results in child quality, and transitory health deviations show deterioration in quality. The positive impact of quality health enables children to overcome sicknesses relatively more easily and helps them in quick recovery.

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