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# "Application of Lavaan for Structural Equation and Path Model on Unmet Healthcare Needs Latent from Demographic and Health Survey Data of Maharashtra State, India"

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**Abstract:** Structural Equation Modeling (SEM) is useful in many areas of research including Medical Research. In R Project, the package lavaan have commercial-quality with fully free open-source to use for latent variable analysis**.** This study aimed to analyze the strength of association latent variable (V623 (Exposure), V624 (Unmet need) and S253 (Had your uterus removed) with other endogenous latent variable of Demographic and Health Survey Program 2019-21 Phase VII, data of Maharashtra State, India. The women age ranged from 16 to 49 years.

Path model of endogenous latent variable f7 (V623 (Exposure), V624 (Unmet need) and S253 (Had your uterus removed)) measured the effect of f1, f2, f3, f4, f5 and f6 latent variable in addition to V613 and V625A exogenous variable, The study revealed that for latent model f7 needs each latent was built-up on sufficient (3 or more) variables in each latent to avoid the Heywood case, even after study data having sufficiently enough large of observation data.

***Keyword:*** *"lavaan", "Path Analysis", "Structural Equation Model ("SEM")", "Latent Variable Analysis","semPath","unmet need", "Heywood case"*

**Introduction:**

In 1952, India grappled with concerns regarding population control, in addition to facing economic growth challenges typical of developing nations. It was during this period that the nation initiated its national family planning program[1,2]. In India, the National Rural Health Mission (NRHM) took on the responsibility of family planning alongside its numerous other duties[3]. It is essential that everyone has access to comprehensive reproductive healthcare, encompassing intentional family planning, contraception, and safe services for pregnancy and childbirth[4]. Female sterilization plays a significant role in family planning within the Indian population[5]. Demographic characteristics, including age, socioeconomic status, education level, place of residence, and marital status, influence the selection of family planning methods [6 7]. Initiating contraception is crucial in reducing both maternal and infant mortality rates[8 9]. The most common reason for postpartum women not using contraception was breastfeeding[10].

Numerous studies have explored factors associated with unmet contraception needs, a crucial aspect of human health. One study employed qualitative analysis to investigate the role of female sterilization in Indian family planning[5]. Another study delved into understanding contraceptive uptake in India, emphasizing the significance of maternal and child health services, utilizing a Discrete-time analysis approach[11]. In a separate investigation, multivariate logistic regression was employed to predict factors related to unsafe abortions, with "safe abortion practices" serving as the reference category in multivariate models[12]. Another study focused on identifying factors linked to contraceptive use among married women of reproductive age, using a logistic regression model[13]. In a related analysis, logistic regression was applied to assess the odds of non-use of modern contraceptive methods across different age groups, while accounting for various confounding factors[14]. In a distinct research conducted by Eimontas, path modeling was utilized to investigate the connection between depressive symptoms in older adults and their unmet healthcare needs. This analysis revealed a direct association between unmet healthcare needs and depression, as well as an indirect pathway through which activity limitations impacted depression by influencing unmet healthcare needs. Additionally, financial conditions indirectly influenced depression by their association with unmet healthcare needs[15].

Lavaan is a statistical package designed for performing Structural Equation Modeling (SEM) within the R software environment. Its development was aimed at catering to the needs of applied researchers, educators, and statisticians. Notably, it is both freely available and fully open-source, offering a standard commercial-quality

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statistical algorithm for modeling latent variables. Over the years, there has been significant growth in the availability of programming packages for structural equation modeling, both for free and commercial usage. However, it's worth noting that some of the most cutting-edge software packages in this field are still closed-source and often require a commercial license[16].

Among these software options, LISREL 8 continues to be one of the most widely adopted choices for conducting structural equation modeling. Additionally, commercial alternatives such as EQS, AMOS, and Mplus are popular among researchers. Besides R, there are non-commercial options available for SEM analysis, such as Mx and gllamm [17, 18, 19, 20, 21, 22].

This study aimed to evaluate the associations between latent variables V623 (Exposure), V624 (Unmet need), and S253 (Had your uterus removed), along with other endogenous latent variables, by utilizing data from the Demographic and Health Survey Program conducted between 2019 and 2021 in the state of Maharashtra, India[23] .

**Material and Methods:**

**Data Collection and Study Design:**

In this study, we employed a multidimensional database sourced from the Demographic and Health Survey (DHS) Program, focusing on Birth Records in Maharashtra State, India. This database encompasses cohort-level information derived from interviews conducted with women aged 16 to 49 years. The dataset can be accessed at https://www.dhsprogram.com/data/dataset_admin/login_main.cfm. The DHS Program is renowned for its extensive data collection, rigorous analysis, and widespread dissemination of accurate and representative information pertaining to population, health, HIV, and nutrition. It maintains a global presence, conducting over 400 surveys in more than 90 countries[23]. We extracted our study's data from Phase VII of the DHS Program, covering the years 2019 to 2021. Out of the initial sample of 57,071, we narrowed our focus to a final sample size of 9,559 participants. The women included in this sample ranged in age from 16 to 49 years, with an average age of 40.78, a standard deviation of 8.52, and a median age of 45 years.

**Variables:**

Data regarding respondents' unmet healthcare needs was extracted from the Birth Record database within the Demographic and Health Survey Program's dataset for the years 2019-21.

To assess unmet healthcare needs, we selected 24 key indicators from the survey, which were derived from responses to various questions posed to the participants. These 24 indicators primarily revolved around specific variables, including S113 (Frequency of cinema or theater attendance), S253 (Uterus removal history), S301 (Current union status), V106 (Highest level of education), V130 (Religion), V136 (Household members count), V137 (Children aged 5 and under in the household), V138 (Eligible women in the household), V212 (Age at first childbirth), V228 (History of terminated pregnancies), V312 (Current contraceptive method), V313 (Method type for current contraceptive use), V361 (Pattern of contraceptive use), V364 (Contraceptive use and intentions), V404 (Current breastfeeding status), V406 (Current abstinence status), V481 (Health insurance coverage), V501 (Current marital status), V502 (Union history), V525 (Age at first sexual activity), V613 (Ideal number of children), V623 (Exposure), V624 (Unmet need), and V625A (Exposure to the need for contraception, definition 3) [23].

**Inclusion criteria:** A participant responded questions along with the variable S253 (had your uterus removed?) with non-Missing data.

**Exclusion Criteria:** A participant not responses to the question along with variable S253 (had your uterus removed?) with Missing data.

**Statistical Analysis:**

In this research, we employed R Project version 4.2.3[24] and RStudio version[25] for our data analysis tasks, supported by the use of rmarkdown[26] and knitr [27, 28, 29] to facilitate the organization of our statistical code. This entailed writing code in sections until we arrived at a satisfactory model for the latent variable.

For the statistical evaluation of the latent variable, we relied on the Lavaan package version 0.6.15 [16] Within Lavaan, the Maximum Likelihood (ML) estimator was employed, and the Optimization method used was NLMINB to ascertain the minimum convergence value. Notably, we encountered an instance where Lavaan version 0.6.15 did not conclude normally, even after 3,077 iterations. We employed semPlot for generating a directed path diagram illustrating the latent model [30] .

**Structural Equation Models (SEM):**

Structural equation modeling (SEM) is a robust analytical technique that broadens the capabilities of statistical methods. It encompasses various components, including LISREL, covariance structures, latent variables, multiple indicators, and path models. Unlike more rigid model assumptions, SEM utilizes regression equations that provide greater flexibility, allowing for the consideration of measurement errors in both independent and dependent variables. Additionally, SEM incorporates factor analyses, enabling the assessment of both direct and indirect effects among factors [31].

At the core of these structural equation techniques lies the fundamental premise that a specific set of constraints can formally define the covariance matrix of the experimental variables. This foundational hypothesis can be expressed as follows:

$$\Sigma = \Sigma(\theta) \tag{1.1}$$

In equation (1.1), Σ (Sigma) denotes the population covariance matrix of the observed variables. The vector θ (theta) encompasses the parameters of the model, and Σ(θ) represents the covariance matrix through a function of θ. Let's consider a simple regression equation: y = γx + ζ, where γ (gamma) denotes the regression coefficient, ζ (zeta) represents the disturbance variable uncorrelated with x, and E(ζ) equals zero. Here, y, x, and ζ are all random variables.

Expressed in terms of equation (1.1), this model becomes:

$$\begin{bmatrix} VAR\ (y) & \cdots \\ COV(x,y) & VAR\ (x) \end{bmatrix} = \begin{bmatrix} \gamma^2 VAR\ (x) + VAR\ (\zeta) & \cdots \\ \gamma\ VAR\ (x) & VAR\ (x) \end{bmatrix} \tag{1.2}$$

Where VAR ( ) and COV ( ) are referred for population variance and covariances of the element in the parenthesis. In equation (1.2) the left-hand side is $\Sigma$, and right-hand side is $\Sigma(\theta)$, with $\theta$, containing $\gamma$, $VAR\ (x)$, and $VAR\ (y) = \gamma^2 VAR\ (x) + VAR\ (\zeta)$. That could be modify this equation to create a multiple regression by adding explanatory variables, or It could add equations and other variables to make it a simultaneous equations system such as that developed in classical econometrics.

Instead of a regression model, consider two random variables, $x_1\ and\ x_2$, that are indicators of a factor (or latent random variable) called $\xi\ (x_i)$. The dependence of the variables on the factor is $x_1 = \xi + \delta_1$ and $x_2 = \xi + \delta_2$, where $\delta_1 (delta)$ and $\delta_2$ are random disturbance terms, uncorrelated with, and $E(\delta_1) = E(\delta_2) = 0$. Equation (1.1) specializes to

$$\begin{bmatrix} VAR\ (x_1) & \cdots \\ COV(x_1,x_2) & VAR\ (x_2) \end{bmatrix} = \begin{bmatrix} \Phi + VAR\ (\delta_1) & \cdots \\ \Phi & \Phi + VAR\ (\delta_2) \end{bmatrix} \tag{1.3}$$

Where Φ (phi) is the variance of the latent factor $\xi$. Here θ consists of three elements: $\Phi, VAR\ (\delta_1)$, and $VAR\ (\delta_2)$. The covariance matrix of the observed variables is a function of these three parameters.

Finally, a simple hybrid of the two preceding cases creates a simple system of equations. The first part is a regression equation of $y = \gamma\xi + \zeta$, where unlike the previous regression the independent random variable is unobserved The last two equations are identical to the factor analysis example: $x_1 = \xi + \delta_1$ and $x_2 = \xi + \delta_2$. assume that $\zeta, \delta_1$ and $\delta_2$ are uncorrelated with $\xi$ and with each other, and that each has an expected value of zero. The resulting structural equation system is a combination of factor analysis and regression-type models, but it is still a specialization of (1.1) [31]:

$$\begin{bmatrix} VAR\ (y) & \cdots & \cdots \\ COV\ (x_1,y) & VAR\ (x_1) & \cdots \\ COV\ (x_2,y) & COV\ (x_2,x_1) & VAR\ (x_2) \end{bmatrix} = \begin{bmatrix} VAR\ (y) & \cdots & \cdots \\ COV\ (x_1,y) & VAR\ (x_1) & \cdots \\ COV\ (x_2,y) & COV\ (x_2,x_1) & VAR\ (x_2) \end{bmatrix} \tag{1.4}$$

According to Structural Equations with Latent Variables[32].

**Path Analysis (PA):**

Sewall Wright, a biometrician, is credited with inventing path analysis, a method used to understand relationships between different factors. Path analysis encompasses three main components: the path diagram, equations that link correlations or covariances with parameters, and the analysis of how effects break down. The path diagram, the first aspect, serves as a visual representation of a system of equations occurring simultaneously. It illustrates how all variables, including disturbances and errors, are interconnected [33] [34] [35] [36] [37]. For instance, Figure 1.1 provides a path diagram that corresponds to these equations:

$$y = \gamma\xi + \zeta$$

$$x_1 = \xi + \delta_1$$

$$x_2 = \xi + \delta_2$$

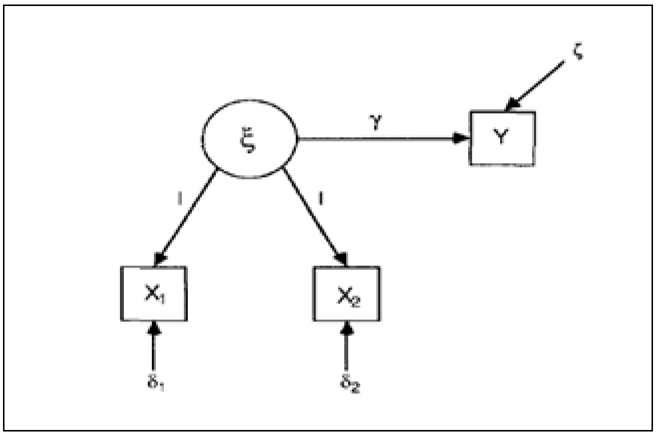


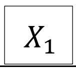
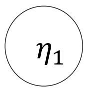
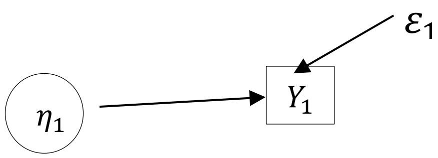
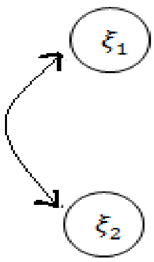
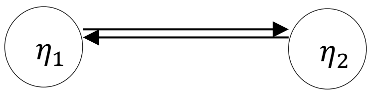

**Figure 1:** Path Diagram Example

In this context $\zeta, \delta_1$ and $\delta_2$ don't have any connections or relationships with each other or with $\xi$. Straight single-headed arrows represent one-way causal influences from the variable at the arrow base to the variable to which the arrow points. The implicit coefficients of one for the effects of $\xi$ on $x_1$ and $x_2$ are made explicit in the diagram[32].

**Path Diagrams (PD):**

A path diagram serves as a visual depiction of a network of interconnected equations that operate simultaneously within a system. Its primary benefit lies in its ability to provide a visual representation of the presumed relationships. To gain a grasp of path diagrams, it is essential to define and comprehend the symbols used within them [32 33 34 35 36 37].

**Table 1:** Provides the Primary Symbols.

| | |
|---|---|
|   | A rectangular or square box represents a variable that is directly observable or manifest in the context. |
|   | A circle or ellipse denotes a variable that is not directly observable, but rather, it represents an underlying or latent factor within the context. |
|   | An unenclosed variable symbolizes a disturbance term, which can encompass errors in either the equation itself or in the measurement process. A straight arrow is used to represent the assumption that the variable at the base of the arrow "influences" or "drives" the variable at the head of the arrow. |
|   | A curved two-headed arrow indicates an unspecified or unexamined relationship between two variables. |
|   | Two straight, single-headed arrows linking two variables indicate a feedback relationship or mutual causation, where each variable influences the other in a reciprocal manner. |

**Latent Variable Model:**

In the context of Bollen's explanation of the Latent Variable Model, variables are categorized as either exogenous or endogenous. Exogenous variables are those deemed independent and are used to explain the behavior of endogenous (dependent) variables. It's important to note that these terms, exogenous and endogenous, are specific to the model being used. What might be an exogenous variable in one model could be considered endogenous in another. Additionally, a variable labeled as exogenous in the model representation may, in reality, be influenced by other variables within the model. Despite these potential variations, the convention is to classify variables as either exogenous or endogenous based on their role within a particular model.

The latent variable model for this example is

$$\eta_1 = \gamma_{11}\xi_1 + \zeta_1 \quad (2.1)$$

$$\eta_2 = \beta_{21}\eta_1 + \gamma_{21}\xi_1 + \zeta_2 \quad (2.2)$$

The equations maintain linearity both in terms of the variables involved and the parameters governing them. The random errors, denoted as $\zeta_1$ and $\zeta_2$ have exhibit expected values (means) of zero and show no correlated with the exogenous variable. The $\beta_{21}$ (referred to as beta) serves as the structural parameter indicating how the expected value of $\eta_2$ changes following a one-unit increase in $\eta_1$, while keeping $\xi_1$constant. The regression coefficients $\gamma_{11}$(referred to as gamma) and $\gamma_{21}$ analogous interpretations. Notably, $\beta_{21}$ pertains to the latent endogenous variable, while $\gamma_{11}$ and $\gamma_{21}$ are associated with the latent exogenous variable.

In matrix notation, we can express Equations (2.1) and (2.2) as follows:

$$\begin{bmatrix}\eta_1\\ \eta_2\end{bmatrix} = \begin{bmatrix}0 & 0\\ \beta_{21} & 0\end{bmatrix}\begin{bmatrix}\eta_1\\ \eta_2\end{bmatrix} + \begin{bmatrix}\gamma_{11}\\ \gamma_{22}\end{bmatrix}[\xi_1] + \begin{bmatrix}\zeta_1\\ \zeta_2\end{bmatrix} \quad (2.3)$$

which is more compactly written as

$$\eta = \beta\eta + \Gamma\xi + \zeta \quad (2.4)$$

Equation (2.4) represents the overarching matrix form of the structural equations within the latent variable model[31 32 38].

**Results:**

The Demographic and health survey participant has 9681 responded to variable S253 (Had your uterus removed?) out of which 72.58% (N = 7027) had not removed uterus and 27.26% (N = 2518) have removed uterus while 0.1% (N = 14) responds Don’t know. among not removed uterus 0.2% Never had Sex, 0.5% Unmet need for spacing and 0.4% have Unmeet need for limiting. As shown in **Table 2** the frequency percentage distribution of V624 (unmet need) with S253 (Had your uterus removed?). The latent variable f1 has 2 variables S113 (Usually go to a cinema hall or theatre to see a movie at least once a month) and S301 (Currently in union) with the 1 and -92.281 estimates. The latent f2 has 5 variables V106 (Highest educational level), V130 (Religion), V136 (Number of household members (listed)), V137 (Number of children 5 and under in household (de jure)) and V138 (Number of eligible women in household (de facto)) with the estimates 1, 0.618, -3563.61, 13.935 and 13.905 respectively. The latent f3 has 1 variable V212 (Age of respondent at 1st birth) with estimates 1. The latent f4 has 5 variables V228 (Ever had a terminated pregnancy), V312 (Current contraceptive method), V313 (Current use by method type), V361 (Pattern of use) and V364 (Contraceptive use and intention) with the estimates 1, 1689.565, 846.858, -752.386 and -831.43 respectively. The latent f5 has 3 variables V404 (Currently breastfeeding), V406 (Currently abstaining) and V481 (Covered by health insurance) with 1, 0.725 and -0.096 estimates. The latent f6 has 3 variables V501 (Current marital status), V502 (Currently/formerly/never in union) and V525 (Age at first sex) with 1, 0.265 and 2476.274 estimate. The latent f7 has built on V623 (Exposure), V624 (Unmet need) and S253 (Had your uterus removed) with 1, 0.062 and 0.012 estimates as shown in **Table 3.**

The regression model for prediction of latent f7 were built with the help of latent f1, f2, f3, f4, f5, f6, V613 and V625A the regression coefficient of model is 1032.407, -26.184, -0.039, -1624.86, -5.112, 3.07, 0.001 and 0.078 respectively as shown in **Table 4.** Similarly, the covariance between the latent f1 and f3 is 0.001. the covariance of latent f3 with f4, f5 and f6 is -0.001, 0.238 and 0.003 as shown in **Table 5**. The variances of V525 (Age at first sex) have -1001.78, V136 (Number of household members (listed)) have 300.57, V130 (Religion), have 34.785 and V624 (Unmet need) have -1.782, for all remaining variance estimates are in between 0 to 1. Similarly, variances for latent variable f3, f5 and f7 are 13.582, 0.097 and 1.753 as shown in **Table 6**.

The covariance matrix of all variables is shown in lower triangular matrix **Table 7.** The variable S113 (Usually go to a cinema hall or theatre to see a movie at least once a month) have 0.047, S301 (Currently in union) have 0.441, V106 (Highest educational level) have 0.917, V130 (Religion) have 34.975, V136 (Number of household members (listed)) have 6.515 and the variable V613 (Ideal number of children) and V624A (Exposure to need for contraception (definition 3) are having covariance 0 with rest all variables as shown in **Table 7**. The directed path diagram shows diagrammatic influence of all statistics on the latent variable f7 as shown in **figure 2**.

**Discussion:**

In this study, path analysis using structural equation model using lavaan which reveal the effect on unmet need, exposure and uterus removal latent f7 as endogenous with other f1, f2, f3, f4, f5 and f6 latent variable in addition to exogenous variable V613 and V625A with regression coefficient 1032.407, -26.184, -0.039, -1624.86, -5.112, 3.07, 0.001 and 0.078, as shown in **Table 4**. The variance of variables V613 (31.043), V624 (4.686), V525 (1465.787), V364 (1.93), V361 (1.682), V313 (1.988), V312 (8.511), V212 (13.556), V136 (6.515) and V130 (34.795) was observed more than 1 as shown in **Table 7**. The Model estimated variance for the variable V525 (-1001.78) and V624 (-1.782) as shown in **Table 6**, The presence of negative variances indicates that certain exogenous variables have estimated covariance matrices that lack positive definiteness. This issue could suggest two potential problems: either it may not be feasible to create a predictive model for the latent variable, or the sample size might be insufficient, as suggested by Joreskog, K.G. and Sorbom, D[39].

As per McDonald's perspective, encountering negative variances and R-squared values exceeding 1 is theoretically implausible. Consequently, this situation is deemed an improper solution, rendering the remaining estimates unreliable. When such variance estimates fall outside expected ranges, it's referred to as a Heywood case. In this study, the primary cause of Heywood cases is the insufficient representation of each factor by an adequate number of variables exhibiting substantial loadings. Therefore, we recommend that researchers, statisticians, or analysts ensure that each common factor is defined by a minimum of three, and ideally, four variables that display significant loadings on it [40].

**Conclusion:**

The link between the endogenous latent variable f7 (comprising V623 (Exposure), V624 (Unmet need), and S253 (Had your uterus removed)) and the exogenous variables f1 (including S113 (Usually go to a cinema hall or theatre to see a movie at least once a month) and S301 (Currently in union)), f2 (encompassing V106 (Highest educational level), V130 (Religion), V136 (Number of household members (listed)), V137 (Number of children 5 and under in the household (de jure)), and V138 (Number of eligible women in the household (de facto))), f3 (encompassing V212 (Age of respondent at 1st birth)), f4 (comprising V228 (Ever had a terminated pregnancy), V312 (Current contraceptive method), V313 (Current use by method type), V361 (Pattern of use), and V364 (Contraceptive use and intention)), f5 (consisting of V404 (Currently breastfeeding), V406 (Currently abstaining), and V481 (Covered by health insurance)), f6 (including V501 (Current marital status), V502 (Currently/formerly/never in union), and V525 (Age at first sex)), V613 (Ideal number of children), and V625A (Exposure to need for contraception (definition 3)) exhibits a Heywood case due to problematic model estimates.

**Limitation:**

Insufficient variables were present for each latent variable due to non-responses or missing values in the data, which ultimately resulted in the occurrence of Heywood cases that couldn't be avoided.

**Conflict of Interest:**

Mr Kishor N Raut and Dr Ashok Y Tayade declare that there is no conflict of Interest.

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**Tables and Graphs:**

**Table 2:** Descriptive Statistics of latent Variable.

| | | Had your uterus removed | | | | | |
|---|---|---|---|---|---|---|---|
| | | No | | Yes | | Don't know | |
| | | Count | Table N % | Count | Table N % | Count | Table N % |
| Unmet need | Never had sex | 15 | .2% | 15 | .2% | 0 | 0.0% |
| | Unmet need for spacing | 45 | .5% | 2 | .0% | 0 | 0.0% |
| | Unmet need for limiting | 39 | .4% | 2 | .0% | 0 | 0.0% |
| | Using for spacing | 90 | .9% | 0 | 0.0% | 4 | .0% |
| | Using for limiting | 4596 | 48.1% | 1676 | 17.5% | 8 | .1% |
| | Spacing failure | 4 | .0% | 0 | 0.0% | 0 | 0.0% |
| | Limiting failure | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |
| | No unmet need | 881 | 9.2% | 7 | .1% | 0 | 0.0% |
| | Not married and no sex in last 30 days | 3 | .0% | 0 | 0.0% | 0 | 0.0% |
| | Infecund, menopausal | 1354 | 14.2% | 816 | 8.5% | 2 | .0% |

**Table 3:** Estimates of Latent Variable

| Latent Variables: | | | | |
|---|---|---|---|---|
| | Estimate | Std.Err | z-value | P(>\|z\|) |
| f1 =~ | | | | |
| S113 | 1 | | | |
| S301 | -92.281 | NA | | |
| f2 =~ | | | | |
| V106 | 1 | | | |
| V130 | 0.618 | NA | | |
| V136 | -3563.61 | NA | | |
| V137 | 13.935 | NA | | |
| V138 | 13.905 | NA | | |
| f3 =~ | | | | |
| V212 | 1 | | | |
| f4 =~ | | | | |
| V228 | 1 | | | |
| V312 | 1689.565 | NA | | |
| V313 | 846.858 | NA | | |
| V361 | -752.386 | NA | | |
| V364 | -831.43 | NA | | |
| f5 =~ | | | | |
| V404 | 1 | | | |
| V406 | 0.725 | NA | | |

| | | | | |
|---|---|---|---|---|
| V481 | -0.096 | NA | | |
| f6 =~ | | | | |
| V501 | 1 | | | |
| V502 | 0.265 | NA | | |
| V525 | 2476.274 | NA | | |
| f7 =~ | | | | |
| V624 | 1 | | | |
| V623 | 0.062 | NA | | |
| S253 | 0.012 | NA | | |

**Table 4:** Regression Co-efficient statistics of Latent Variable.

| Regressions: | | | | |
|---|---|---|---|---|
| | Estimate | Std.Err | z-value | P(>\|z\|) |
| f7 ~ | | | | |
| f1 | 1032.407 | NA | | |
| f2 | -26.184 | NA | | |
| f3 | -0.039 | NA | | |
| f4 | -1624.86 | NA | | |
| f5 | -5.112 | NA | | |
| f6 | 3.07 | NA | | |
| V613 | 0.001 | NA | | |
| V625A | 0.078 | NA | | |

**Table 5:** Covariance statistics of Latent Variable.

| Covariances: | | | | |
|---|---|---|---|---|
| | Estimate | Std.Err | z-value | P(>\|z\|) |
| f1 ~~ | | | | |
| f2 | 0 | | | |
| f3 | 0.001 | | | |
| f4 | 0 | | | |
| f5 | 0 | | | |
| f6 | 0 | | | |
| f2 ~~ | | | | |
| f3 | 0 | | | |
| f4 | 0 | | | |
| f5 | 0 | | | |
| f6 | 0 | | | |
| f3 ~~ | | | | |
| f4 | -0.001 | | | |
| f5 | 0.238 | | | |
| f6 | 0.003 | | | |
| f4 ~~ | | | | |
| f5 | 0 | | | |
| f6 | 0 | | | |
| f5 ~~ | | | | |
| f6 | 0 | | | |

**Table 6:** Model Estimated Variance.

| Variances: | | | | |
|---|---|---|---|---|
| | Estimate | Std.Err | z-value | P(>\|z\|) |
| .S113 | 0.047 | | | |
| .S301 | 0.428 | | | |
| .V106 | 0.919 | | | |

| | | | | |
|---|---|---|---|---|
| .V130 | 34.785 | | | |
| .V136 | 300.57 | | | |
| .V137 | 0.884 | | | |
| .V138 | 0.751 | | | |
| .V212 | 0 | | | |
| .V228 | 0.102 | | | |
| .V312 | 0.608 | | | |
| .V313 | 0.002 | | | |
| .V361 | 0.114 | | | |
| .V364 | 0.016 | | | |
| .V404 | 0.033 | | | |
| .V406 | 0.036 | | | |
| .V481 | 0.145 | | | |
| .V501 | 0.442 | | | |
| .V502 | 0.086 | | | |
| .V525 | - 001.78 | | | |
| .V624 | -1.782 | | | |
| .V623 | 0.881 | | | |
| .S253 | 0.28 | | | |
| f1 | 0 | | | |
| f2 | 0 | | | |
| f3 | 13.582 | | | |
| f4 | 0 | | | |
| f5 | 0.097 | | | |
| f6 | 0 | | | |
| .f7 | 1.753 | | | |

**Table 7:** Lower tell Covariance Matrix

| | S113 | S301 | V106 | V130 | V136 | V137 | V138 | V212 | V228 | V312 | V313 | V361 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S113 | 0.047 | | | | | | | | | | | |
| S301 | -0.001 | 0.441 | | | | | | | | | | |
| V106 | 0 | 0 | 0.917 | | | | | | | | | |
| V130 | 0 | 0.002 | 0 | 34.795 | | | | | | | | |
| V136 | 0.01 | -0.042 | 0.002 | -0.124 | 6.515 | | | | | | | |
| V137 | 0.005 | -0.022 | 0.001 | -0.063 | 1.482 | 0.879 | | | | | | |
| V138 | 0.001 | -0.006 | 0 | -0.017 | 0.398 | 0.203 | 0.747 | | | | | |
| V212 | 0.053 | -0.228 | 0 | 0.005 | -0.107 | -0.055 | -0.015 | 13.556 | | | | |
| V228 | 0 | 0 | 0 | 0 | -0.001 | -0.001 | 0 | -0.001 | 0.102 | | | |
| V312 | -0.009 | 0.038 | -0.001 | 0.047 | -1.107 | -0.565 | -0.152 | -1.128 | 0.007 | 8.511 | | |
| V313 | -0.004 | 0.019 | 0 | 0.024 | -0.555 | -0.283 | -0.076 | -0.565 | 0.004 | 3.961 | 1.988 | |
| V361 | 0.004 | -0.017 | 0 | -0.021 | 0.493 | 0.252 | 0.068 | 0.502 | -0.003 | -3.519 | -1.764 | 1.682 |
| V364 | 0.004 | -0.019 | 0 | -0.023 | 0.545 | 0.278 | 0.075 | 0.555 | -0.004 | -3.889 | -1.949 | 1.732 |
| V404 | 0.004 | -0.019 | 0 | -0.016 | 0.363 | 0.185 | 0.05 | 0.24 | 0 | -0.337 | -0.169 | 0.15 |
| V406 | 0.003 | -0.012 | 0 | -0.01 | 0.233 | 0.119 | 0.032 | 0.154 | 0 | -0.216 | -0.108 | 0.096 |
| V481 | 0 | 0.002 | 0 | 0.001 | -0.033 | -0.017 | -0.005 | -0.022 | 0 | 0.031 | 0.015 | -0.014 |
| V501 | 0 | 0 | 0 | 0 | -0.001 | -0.001 | 0 | 0.005 | 0 | 0.005 | 0.003 | -0.002 |
| V502 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.001 | 0 | 0.002 | 0.001 | -0.001 |
| V525 | -0.025 | 0.109 | -0.001 | 0.057 | -1.326 | -0.677 | -0.182 | 6.346 | 0.007 | 6.869 | 3.443 | -3.059 |
| V623 | 0 | 0 | 0 | 0 | 0.001 | 0 | 0 | 0.002 | 0 | -0.016 | -0.008 | 0.007 |
| V624 | 0.009 | -0.04 | 0 | -0.014 | 0.317 | 0.162 | 0.043 | 0.56 | -0.005 | -5.48 | -2.747 | 2.44 |
| S253 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.004 | -0.002 | 0.002 |
| V613 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| V625A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Continued **Table 7** : Lower tell Covariance Matrix

| | V364 | V404 | V406 | V481 | V501 | V502 | V525 | V623 | V624 | S253 | V613 | V625A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S113 | | | | | | | | | | | | |
| S301 | | | | | | | | | | | | |
| V106 | | | | | | | | | | | | |
| V130 | | | | | | | | | | | | |
| V136 | | | | | | | | | | | | |
| V137 | | | | | | | | | | | | |
| V138 | | | | | | | | | | | | |
| V212 | | | | | | | | | | | | |
| V228 | | | | | | | | | | | | |
| V312 | | | | | | | | | | | | |
| V313 | | | | | | | | | | | | |
| V361 | | | | | | | | | | | | |
| V364 | 1.93 | | | | | | | | | | | |
| V404 | 0.166 | 0.13 | | | | | | | | | | |
| V406 | 0.106 | 0.07 | 0.087 | | | | | | | | | |
| V481 | -0.015 | -0.01 | -0.006 | 0.146 | | | | | | | | |
| V501 | -0.003 | 0 | 0 | 0 | 0.443 | | | | | | | |
| V502 | -0.001 | 0 | 0 | 0 | 0 | 0.087 | | | | | | |
| V525 | -3.38 | -0.041 | -0.026 | 0.004 | 1.261 | 0.393 | 1465.787 | | | | | |
| V623 | 0.008 | 0 | 0 | 0 | 0 | 0 | -0.015 | 0.906 | | | | |
| V624 | 2.697 | 0.093 | 0.059 | -0.008 | -0.004 | -0.001 | -5.3 | 0.182 | 4.686 | | | |
| S253 | 0.002 | 0 | 0 | 0 | 0 | 0 | -0.004 | 0 | 0.05 | 0.281 | | |
| V613 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.078 | 0 | 31.043 | |
| V625A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.017 | 0 | 0.05 | 0.37 |

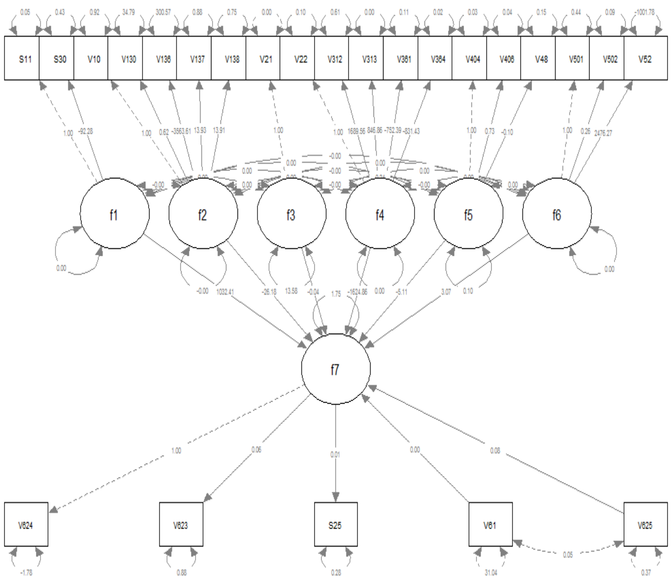


**Figure 2:** Directed Path Diagram for Latent V623 (Exposure), V624 (Unmet need) and S253 (Had your uterus removed) of Maharashtra State, India.