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Amarjit Singh Sethi
Punjab School of Economics Guru Nanak Dev University, India

Ritu Pandhi
Baring Union College, India

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Nexus between Calorie Inequalities and Health among Major Indian States

Amarjit Singh Sethi[1] and Ritu Pandhi[2]

[1]Professor (Retired), Punjab School of Economics Guru Nanak Dev University, Amritsar (India) – 143 005
(E-mail: ajss.gndu@gmail.com)

[2]Assistant Professor, Baring Union College, Batala (India) – 143531
(E-mail: ritu.pandhi@yahoo.com)

Abstract

This paper aims at making an assessment of temporal shifts in relative positioning of the major Indian states, jointly through the chief concomitants of health, as also through the measures of calorie inequalities. The task was accomplished through *factor analysis* (with *promax oblique rotation*), duly coupled with *canonical correlation analysis,* on the information on 16 indicators of health during *three rounds* for *seventeen* major Indian states. As per the findings, major determinants of health status have undergone voluminous reshuffling during the study span. Through *composite index*, states like Tamil Nadu, Maharashtra and Kerala were observed to have undergone perceptible temporal improvements in health status, whereas the so-called better-off states like Punjab and Gujarat have slipped fairly sharply in their relative rankings. As per FGT(2) index (due to Foster *et al.*, 1984, 2010; measuring *relative deprivation*), the averaged inequalities, within each of rural and urban regions, were highly significantly different among the states as also among the rounds. Temporally, the inequalities portrayed an inverted-U pattern. Gravity of the situation on calorie inequalities in south Indian states (like Tamil Nadu, Karnataka and Kerala) was alarming whereas, on the other extreme, the same in certain north-Indian hilly states (like Himachal Pradesh and Jammu & Kashmir) was manageable. Further, through *panel data estimation*, association between the composite index of health status and FGT(2) measure of the inequalities was indirect and statistically significant. There was a feeble indication of an indirect association between the measure of inequalities and per capita Income. However, association between the composite index of health and per capita income was direct and very robust. Thus, as a policy measure, there is a dire need for shifting priorities in favour of investment on both physical and social health infrastructure, particularly in laggard states and in those states which have undergone a rapid slippage in their ranking. *Public-private-partnership model* in this important social activity (which otherwise has remained a soft target by the governments), may prove beneficial.

Key Words: Calorie Inequalities, Time Series Factor Analysis, Promax Oblique Rotation, Composite Index, Canonical Correlation Analysis, FGT Index.

JEL Codes: C33, C38, I14, I15, R11, R58.

1. Introduction

As per WHO (1946), health of an individual is defined as a state of complete physical, mental and social well being, and not merely absence of disease or infirmity. A community would be healthy if a large majority of the individuals constituting the community are so. The basic necessities for anyone to be healthy are availability of adequate amount of food (qualitative enough so as to meet the bare minimal nutritional requirements), shelter and clothing which, however, could be met only if there is a sufficient scope of income generation.

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Health status of a cohort of people is characterized by a multiplicity of factors – demographic, physical as well as social health infrastructure. Relative significance of these factors may differ temporally as well as spatially. Furthermore, nutritional requirements necessary for keeping good health are also known to vary across individuals and over time due to a multiplicity of reasons, generally not known to us (Ravallion, 1992). In fact, an adequate nutritional intake by the people is accepted as a meaningful yardstick for the success story of development policies of a nation.

Among Indian states, there are known to exist wide inequalities in the level of development. Although hunger and malnutrition are common, yet the extent and pattern differ from state-to-state. Nutritional status of the population depends not merely on food production and availability but more so on quantity and quality of food consumption. Uptil mid-sixties, nutritional problem was considered as the one associated with protein deficiency, especially in respect of quality protein from animal food. In line with the experience of a large majority of the developing economies, nutritional levels of the people are inadequate.

This paper aims at making an assessment of temporal shifts in relative positioning of the major Indian states, jointly through the chief concomitants of health, as also through the measures of calorie inequalities. An evaluation has also made on the relative positioning of the states, jointly on the basis of the so-identified determinants, so as to enable policy-makers to adopt policies conducive for balanced growth.

The paper has been organized into six sections in all, including the present one. The second section deals with a brief review of the related literature, so as to assist us in having a feel of the research gaps, if any, which possibly could be filled through the present study. A brief mention of the data base has been made in the third section, whereas analytical techniques adopted in the study have been mentioned in the fourth section. The fifth section is devoted to a brief discussion on the results obtained, first on health issues and then on calories inequalities. And, finally, concluding remarks and policy implications have been given in the sixth section.

2. Literature Reviewed

In the Indian context and elsewhere, a number of studies have been carried out on temporal and interregional status of health and nutrition, some of which have been thematically reviewed in this section.

Calorie deficiency has been a matter of grave concern; in almost all classes of people, there was no group that was protein deficient, but no group that was not calorie deficient (Gopalan, 1970; Sukhatme, 1970; Gopalan *et al.,* 1971; Ghassemi, 1972). Malnutrition caused by calorie deficiency assumed central concern, especially among economists like Dandekar and Rath (1971), who estimated poverty line on the basis of minimum calorie requirement; proportion of people living below this level was considered as a measurement of poverty. A glaring 60 percent of the real population was below the all India average intake in respect of calorie and all other nutrients (Chatterjee and Bhattacharya, 1974).

Rao (1971) observed that less developed states were moving towards national composite rate and that inter-state disparities were reducing. However, Rao (1973) opined that disparities did not come down at the pace these should have been during the course of 15 years of planning. Without making a mention of the extent of inequality in nutritional intake, Dasgupta (1983) examined the intake of different nutrients for people of different age-sex-activity group. Bardhan (1974a, 1974b) and Srinivasan (1974) have made significant contributions in distributional aspects of income and poverty in India. Expressing his views on 'Some Nutritional Puzzles', Rao (1981) emphasised on the need for balanced diet that would secure both the energy intake and the nutrients needed for good health. Dasgupta (1984) made an assessment of the average intake of calories and proteins in India. Making use of certain indices of inequality and under-nutrition, he found that although nutritional inequality was more evident in rural areas, yet the problem was not only of distribution but also of availability itself. Rao (2000) measured the effects of major forces affecting consumption of pulses in rural regions of two districts of Delhi, and found that the income effect of pulses changed from positive to negative, thus indicating a rise in the general standard of living. He also observed a shift from consumption of energy food to consumption of body building and protective foods. Certain other studies, such as those due to Datta and Ganguly (2002), Randhawa and Chahal (2005), Giri (2006), Musebe and Kumar (2006), Nasurudeen *et al.* (2006), Chadha (2007), Mittal (2007), Kumar *et al.* (2007), *etc.* have also arrived at the general conclusion that the share of non-cereal items in monthly per capita expenditure has consistently increased over time in both rural and urban regions of India. Das (1999) observed that the factors like education, availability of food, minimum purchasing power, facilities like safe drinking water, health infrastructure, *etc.,* played an important role in development process. Similarly, as per Sethi (2003), social sector strengthening (through increased government expenditure on health and education) tends to supress the incidence of poverty *via* providing more employment opportunities, bringing down death rate, and increasing literacy rate. Nair (2007) analyzed inter-state differentials in malnourishment among children in India on the basis of National Family Health Surveys: 1992-93, 1998-99, and 2005-06. The study brought out the prevalence of widespread disparities, and indicated that differentials were increasing over time. Kumar (2011) noticed that wide regional disparities in women's status were present across states, which have persisted over time with little change in the development ranking of the Indian states.

As regards relative status of health among different states in India, life expectancy at birth is an indicator of improvement, whereas each of infant mortality rate and crude birth rate are the indicators of deterioration (Pathak and Gaur, 1997). Au *et al.* (2001) made an assessment of regional variations in the physical and mental health of patients receiving primary care in the largest integrated health care system in the United States. While examining the extent of inequalities in health care and nutritional status across casts and tribes among Indian states, Roy *et al.* (2004) observed that health services did not reach the disadvantaged sections. As per Kathuria and Sankar (2005), health outcomes of Indian states in rural areas were positively related to the level of health infrastructure in terms of access to facilities and availability of skilled professionals. In his gender-related study, Gupta (2009) observed the presence of a strong interrelationship between economic well-being, health & education, human development index, and social opportunities of women. Kumari (2011) observed that apart from the presence of wide inter-district disparities in Uttar Pradesh, there were some regions that performed well in educational attainment but were poorly placed in terms of health attainment, and *vice-versa*.

Sethi and Pandhi (2011a, 2011b) observed that a major chunk of consumption expenditure in India stands incurred on items like Milk & Milk Products and Cereals, whereas the least expenditure was allocated to Fruits & Nuts and Spices. Sethi and Pandhi (2012a, 2013) estimated the extent of inequalities in calorie intake among the Indian states/ union territories (UTs), and also identified the chief determinants of the inequalities. In another empirical study, Sethi and Pandhi (2012b) observed the presence of high-profile gaps among states and UTs with respect to per capita per diem intake of calories, protein, and fat, separately for rural and urban regions. Next, Sethi and Pandhi (2014) examined the extent of interstate divergences with respect to consumption expenditure on major food items in India, and also to identify the clusters of the states at a similar level of the expenditure. The present paper is a further step, wherein we have made an attempt to seek knowledge on the extent of interlinkage between calorie inequalities and health status among the Indian states which, in turn, is expected to provide us with a useful input for appropriate policy formulation at the regional level.

3. Data

For measuring calorie inequalities, data on the distribution of households by calorie intake level for different MPCE (*i.e.,* Monthly Per Capita Expenditure) classes of each of the states under study (separately for rural and urban regions), were culled out from the Reports of 55th, 61st and 68th Rounds of NSSO on Nutritional Intake in respect of *seventeen* major Indian states. As has been mentioned in Sethi and Pandhi (2012a), the data provides the two-way distribution of persons by calorie intake level. For constructing these tables, NSSO has used the information on per 1000 distribution of households by MPCE classes and by class intervals of actual calorie intake level as percent of normative level of 2700 kcal, for both rural and urban areas. The major states considered in the study were: Andhra Pradesh (ANP), Assam (ASM), Bihar (BHR), Gujarat (GUJ), Haryana (HAR), Himachal Pradesh (HMP), Jammu and Kashmir (JNK), Kerala (KRL), Karnataka (KTK), Madhya Pradesh (MDP), Maharashtra (MHR), Orissa (ORS), Punjab (PNB), Rajasthan (RAJ), Tamil Nadu (TND), Uttar Pradesh (UTP), West Bengal (WBN).

For the purpose of identification of the major determinants of health, numerical information was compiled on as many as 16 indicators of health at three points in time: 1999-00, 2004-05, and 2011-12. The points had a close proximity with three Rounds of National Sample Surveys Organisation (NSSO) on Nutritional Intake in India: 55th (July, 1999 - June, 2000), 61st (July, 2004 - June, 2005) and 68th (July, 2011 - June, 2012). The indicators considered in the study were a mixture of demographic (or endogenous) variables [*viz.*, Birth Rate (BRRT, per 1000 population p.a.), Death Rate (DTRT, per 1000 population p.a.), Infant Mortality Rate (IMRT, per 1000 live births p.a.), and Life Expectancy at Birth (LEBR, in years)]; exogenous variables on physical and social infrastructure of health [*viz.*, Number of Hospitals per 100 Sq Km (NHPK), Number of Hospital Beds per Lakh of Population (NBPL), Number of Sub-Centers per 100 Sq Km (SBPK), Number of Primary Health Centers per 100 Sq Km (PHPK), Number of Community Health Centers per 100 Sq Km (CHPK), Number of Doctors per Lakh of Population (DCPL), Number of Pharmacists per Lakh of Population (PRPL), Number of Auxiliary Nursing Midwives per Lakh of Population (ANPL), Number of Lady Health Visitors per Lakh of Population (LVPL), Number of Nurses per Doctor (NRPD), and Number of Assistants per Doctor (NAPD)]; and level of living [*viz.* Per Capita Income (PCIN, in Rs'000)].

4. Analytical Techniques

For accomplishing the task, we have made use of analytical techniques, like *FGT(2) measure* of nutritional inequalities, *canonical correlation analysis* and *exploratory factor analysis*. As per requirements of the latter two multivariate analytical techniques, each of the manifest variables were considered in comparable terms (either in terms of per unit population or in terms of per unit area) and were suitably re-expressed, if required, in such a manner that higher value of each of the variables indicated towards better health status of a state. For instance, Death Rate was transformed into 1000/DTRT. Similar was the treatment in respect of Birth Rate and Infant Mortality Rate. Before subjecting the transformed data to the analysis, each of the variables were duly standardized for their mean (μ) and standard deviation (σ).

4.1. FGT Measure of Calorie Inequalities

For the measurement of calorie inequalities, we have made use of the well-known FGT index of nutritional inequalities, as proposed by Foster, *et al.* (1984, 2010):

$$\text{FGT}(\alpha) = \frac{1}{n}\sum_{i=1}^{k} f_i \left[\frac{z - y_i}{z}\right]^{\alpha}; \alpha \geq 0 \qquad \text{... (1)}$$

where, n stands for the size of the population; k for the number of classes below the minimum level of calorie requirement z; f_i for frequency of the i^{th} class below the nutritional level z; and y_i for average calorie intake of people in the i^{th} class below the level z. Evidently, FGT measure is a weighted sum of the poverty gap ratios $\left[\frac{z - y_i}{z}\right]$ of the poor.

As has already been indicated in Sethi and Pandhi (2012), the FGT measure's *axiomatic* properties, like *versatility*, *additive decomposability*, *sub-group consistency*, and *distributive sensitivity*, make it to be a useful measure for undernourishment inequalities. With $\alpha = 2$, the index exhaustively takes into account three aspects, *viz.,* the number of undernourished in the population, depth of their undernourishment and their relative deprivation (Osberg and Xu, 2008). Consequently, in the present paper, we have made use of FGT (2) version of inequalities in calorie intake from the compiled information, separately in respect of rural and urban regions for each of the states under consideration.

4.2. Canonical Correlation Analysis

Canonical correlation analysis, introduced originally by Hotelling way back in 1935, is known to be a very versatile multivariate technique for identifying relationships between two groups of variables. The analysis aims primarily at studying overall association between linear composites (called *canonical variates*) between two multivariate data sets (Akbas and Takma, 2005; Menderes *et al.,* 2005). Intrinsically, the analysis aims at identifying the *optimum structure* or *dimensionality* of each variable set that maximizes the relationships between the two sets of variables. An added advantage of the canonical correlation analysis is that it places the minimal restrictions on the types of data on which it operates.

Let there be p variates in Group-1 (say, endogenous variables of health) and q variates in Group-2 (say, endogenous variables of health), so that $p \leq q$. Let the variates in the two groups be X_1, X_2, …, X_p and Y_1, Y_2, …, Y_q , respectively. Suppose we write down the matrix of inter-correlation coefficients between the variables as

$$R = \begin{pmatrix} r_{x_1,x_1} & r_{x_1,x_p} & r_{x_1,y_1} & r_{x_1,y_q} \\ \\ r_{x_1,x_1} & r_{x_1,x_p} & r_{x_1,y_1} & r_{x_1,y_q} \\ r_{y_1,x_1} & r_{y_1,x_p} & r_{y_1,y_1} & r_{y_1,y_q} \\ \\ r_{y_q,x_1} & r_{y_q,x_p} & r_{y_q,y_1} & r_{y_q,y_q} \end{pmatrix} = \begin{pmatrix} R_{xx} & R_{xy} \\ R_{yx} & R_{yy} \end{pmatrix} \qquad (2)$$

where

$$R_{xx} = \begin{pmatrix} r_{x_1,x_1} & r_{x_1,x_p} \\ \\ r_{x_p,x_1} & r_{x_p,x_p} \end{pmatrix};\ R_{yy} = \begin{pmatrix} r_{y_1,y_1} & r_{y_1,y_q} \\ \\ r_{y_q,y_1} & r_{y_q,y_q} \end{pmatrix};\ R_{xy} = \begin{pmatrix} r_{x_1,y_1} & \cdots & r_{x_1,y_q} \\ \\ r_{x_p,y_1} & & r_{x_p,y_q} \end{pmatrix};\ \text{and } R_{yx} = R_{xy}^{T}$$

Consider the linear combinations among the variables (each expressed in terms of deviations from the corresponding mean values):

$$z_x = \sum_{i=1}^{p} u_i x_i \quad \text{and} \quad z_y = \sum_{j=1}^{q} v_i y_i \tag{3}$$

Conceptually speaking, *canonical correlation* is the *maximum correlation that exists between the variates* z_x *and* z_y. Following Lindemann *et al.* (1980) and Tabachnick & Fidell (1989), the product moment correlation coefficient between the composite variables z_x and z_y is expressible as

$$r_{z_x, z_y} = \frac{\sum_{t=1}^{n} z_x\ z_y}{\sqrt{\sum_{t=1}^{n} z_x^2 \sum_{t=1}^{n} z_y^2}} = \frac{c'\, R_{xy}\ d}{\sqrt{\left(c'\, R_{xx}\ c\right)\left(d'\, R_{yy}\ d\right)}} \tag{4}$$

The vectors of weights c and d were chosen (with the help of *eigen roots* and *eigen vectors*) so as to ensure maximization of r_{z_x, z_y}.

Next, by following Lindemann *et al.* (1980), the overall *redundancy measure* (due to Stewart and Love, 1968) in the X-set, given that the entire set of canonical variates based on the Y-set is available, was computed. The redundancy measure in the Y-set, given that the entire set of canonical variates based on the X-set is available, was computed similarly. (Computational steps for the measures are given in details in Sethi and Kumar, 2013).

4.3. Exploratory Factor Analysis

In order to accomplish the twin objectives of (a) making an assessment of temporal shifts in relative positioning of the major Indian states, jointly through the chief concomitants of health, and (b) making an evaluation of the relative positioning of the states, jointly on the basis of the so-identified determinants, we have made use of *exploratory factor analysis* approach. This *dimensionality-reduction* statistical technique aimed at disclosing *latent traits*, called *factors*, which presumably underlie a regions' performance on the given set of observed variables and explain their interrelationships. These factors are not directly measurable, but are instead latent or hidden random variables or constructs, with the observed measures being their indicators or manifestations in overt behavior (Raykov and Markoulides, 2008). One of the major objectives of Factor Analysis (FA) was to explain the pattern of the manifest (observable) variable interrelationships with as few (latent) factors as possible. Thereby, the factors are expected to be substantively interpretable and to explain why certain sets (or subsets) of observed variables are highly correlated among themselves. More specifically, the aims of FA could be summarized as: (i) to determine if a smaller set of factors could explain the interrelationships among a number of original variables; (ii) to find out the number of these factors; (iii) to interpret the factors in subject-matter terms; and (d) to provide estimates of their individual factor scores, so as construct composite index for evaluating relative performance of the major Indian states.

As regards the underlying model in factor analysis technique, let us denote a column vector of p observed variables by $\underline{x} = (x_1, x_1, ..., x_p)'$, wherein each of the variables were *standardised* (in the usual way for their *mean* and *standard deviation*) beforehand so that each had a zero mean and unit variance. The FA model is then put as:

$$\begin{aligned} x_1 &= \lambda_{11}F_1 + \lambda_{12}F_2 + \quad + \lambda_{1m}F_m + \varepsilon_1 \\ x_2 &= \lambda_{21}F_1 + \lambda_{22}F_2 + \quad + \lambda_{2m}F_m + \varepsilon_2 \\ \\ x_p &= \lambda_{p1}F_1 + \lambda_{p2}F_2 + \quad + \lambda_{pm}F_m + \varepsilon_p \end{aligned} \qquad \text{... (5)}$$

where $F_1, F_2, \quad F_m$ (with $m < p$) are the *factors*; λ_{ij} are *loadings* (of the i^{th} observed measure on j^{th} factor); and $\varepsilon_1, \varepsilon_2, \quad, \varepsilon_p$ are *error* or *uniqueness terms* $(i = 1, 2, \quad, p; j = 1, 2, \quad, m)$. The loadings λ_{ij} might be viewed as the extent to which the observed variable x_i is associated with the factor F_j. A salient loading is the one which is significantly high to assume that a relationship exists between the variable and the factor. In addition, it means that the relationship is high enough, so that the variable can aid in interpreting the factor, and *vice versa* (Gorsuch, 1974).

As per the standard methodology (like the one adopted in *principal component analysis*), factors F_i and F_j would turn out to be orthogonal in the sense that manifest variables constituting a factor would be of the similar nature (or are complimentary) with respect to the phenomenon under study, but the variables constituting different factors would be independent.

The above system of equations could also be written as

$$\underline{x} = \Lambda \underline{F} + \underline{\varepsilon} \tag{6}$$

where $\underline{x}$ is $p \times 1$ vector of observed variables, $\Lambda = (\lambda_{ij})$ is $p \times m$ matrix of factor loadings, $\underline{F}$ is $p \times 1$ vector of factors, and $\underline{\varepsilon}$ is $p \times 1$ vector of error (or, uniqueness) terms (with zero mean), assumed to be unrelated among themselves and with the factors in $\underline{F}$. Due to orthogonalilty of factors, variance of the observed variables is expressible as

$$V(x_i) = h_i^2 + \psi_i \qquad (i = 1, 2, \quad , p) \tag{7}$$

where h_i^2 $(= \sum_{i=1}^{n} \lambda_{ij}^2)$ stands for *communality*, which denotes the extent of variance (=1) in the given observed measure x_i, which stands explained by the common factors F_1, F_2, …, F_m, and may be conceptually viewed as something like *coefficient of multiple determination* (R^2) if x_i were regressed upon the m factors extracted. The remaining extent of variance ($= \psi_i$) in x_i is *uniqueness term.* In order to enhance the extent of variance explained by the factors in the observed variables, as also to come out with a conspicuous extraction of the *factors,* we have made use of *promax oblique rotation of the axes.* The number 'm' of factors extracted (through the *pca* option) was decided through *eigen values* of the components, duly coupled with the rationale of *steepest descent* in *scree plot*.

Seeking the help of OECD (2008), and making use of the matrix of Λ of loadings, *composite index* for each of the states was constructed through the following steps:

(i) For each of m factors extracted, the proportion of variance explained (say, pve_j) in the data set was computed as

$$\text{pve}_j = \frac{\sum_{i=1}^{p} \lambda_{ij}^2}{\text{trace(icm)}} \tag{8}$$

(ii) For the i^{th} observed variable, let the maximum loading (say, λ_i^*) is realized on a particular factor having a proportion of variance explained $= \text{pve}^*$ (say)

(iii) For this observed variable, weight (W_i) was computed as

$$W_i = \lambda_i^* \times \text{pve}^* \tag{9}$$

(iv) And, finally, composite index (CMP_t) for the t^{th} district was computed as

$$\text{CMP}_t = \frac{W_i \; x_{ti}}{\sum_{i=1}^{p} W_i} \tag{10}$$ where

x_{ti} refers to the standardized value of the i^{th} observed variable in respect of t^{th} state. Computed values of the composite index formed the basis for gauging relative positioning of the states, jointly on the basis of the study variables, with respect health status.

For carrying out different types of analyses, suitably adapted codes in R-language (solely by the senior author of this paper) were made use of. For factor analysis, in particular, we have sought the help of 'FAiR' package (due to Goodrich, 2012) and 'tsfa' package (due to Gilbert and Meijer, 2012) for applicability in balanced panel data framework.

5. Results and Discussion

Results obtained from the study have been discussed in brief under the following sub-heads:

5.1. Calorie Inequalities among the Major Indian States

For measuring calorie inequalities among the states, we have made use of the data on the distribution of households by calorie intake level for different MPCE (separately for rural and urban regions) of each of the states under study. For the purpose of clarification on the format of data used, we have presented such a distribution for rural regions of India as whole in respect of 55^{th} Round of NSSO (Table 5.1.1).

Table 5.1.1. Per Thousand Distribution of Households by Calorie Intake Level for Each MPCE Class in Rural India – 55th Round

MPCE Class (Rs)	Calorie Intake Level									
	< 70	70-80	80-90	90-100	100-110	110-120	120-150	≥ 150	All Classes	SMP HHS
< 225	654	177	98	44	13	7	3	3	1000	2547
225-255	416	239	185	93	40	16	9	3	1000	2451
255-300	311	231	200	134	66	28	23	7	1000	5147
300-340	182	207	231	173	104	48	43	11	1000	5588
340-380	145	181	225	179	127	69	61	14	1000	5892
380-420	96	153	190	199	149	94	96	23	1000	5895
420-470	71	115	170	200	161	110	131	42	1000	6783
470-525	53	90	150	176	171	127	173	60	1000	6635
525-615	37	72	130	156	161	134	222	88	1000	8253
615-775	27	46	88	134	145	141	274	145	1000	9383
775-950	19	34	61	110	126	126	295	230	1000	5337
≥ 950	23	16	44	69	107	107	271	381	1000	7474
All classes	134	124	151	149	92	92	143	82	1000	69206

The computed values of calorie inequalities, as estimated through the FGT(2) measure (equation 10) have been exhaustively presented in Table 5.1.2. As per the table, there obviously have been wide inequalities in the calorie intake at different levels: between states, between rounds, and between regions. For instance, within rural regions, the extent of inequalities during 55th round was as low as 0.0085 in Himachal Pradesh, but was as high as 0.0550 in Tamil Nadu. Further, within urban regions, the extent of inequalities in Maharashtra was as high as 0.0506 during 61st round, but was a mere 0.0094 during 68th round. Similarly, within Uttar Pradesh state, the extent of inequalities during 68th round was a mere 0.0025 among rural regions, but was comparatively much higher at 0.0129 among urban regions.

However, in order to draw concrete conclusions about differentials in inequalities in calorie intake among the states, the measurements made through the FGT(2) index (Table 5.1.2) were subjected to *three-way ANOVA* technique (with Rounds, States and Regions as the factors). The analysis revealed that within each of rural and urban regions, the averaged inequalities were

Table 5.1.2. Computed Values of FGT(2) Index of Inequality among Major Indian States during the Three Rounds – Rural, Urban and Combined Regions

State	Rural				Urban				Combined			
	Round			Mean	Round			Mean	Round			Mean
	55th	61st	68st		55th	61st	68st		55th	61st	68st	
ANP	0.0326	0.0328	0.0158	0.0271	0.0369	0.0468	0.0089	0.0309	0.0348	0.0398	0.0124	0.0290
ASM	0.0461	0.0253	0.0252	0.0322	0.0298	0.0284	0.0105	0.0229	0.0380	0.0268	0.0178	0.0276
BHR	0.0283	0.0249	0.0220	0.0251	0.0263	0.0304	0.0103	0.0223	0.0273	0.0276	0.0161	0.0237
GUJ	0.0337	0.0399	0.0273	0.0336	0.0328	0.0416	0.0110	0.0285	0.0332	0.0407	0.0192	0.0310
HAR	0.0158	0.0222	0.0106	0.0162	0.0295	0.0407	0.0075	0.0259	0.0226	0.0314	0.0090	0.0210
HMP	0.0085	0.0095	0.0018	0.0066	0.0092	0.0154	0.0028	0.0091	0.0088	0.0124	0.0023	0.0079
JNK	0.0088	0.0102	0.0073	0.0088	0.0082	0.0091	0.0035	0.0069	0.0085	0.0096	0.0054	0.0079
KRL	0.0399	0.0391	0.0222	0.0337	0.0393	0.0516	0.0126	0.0345	0.0396	0.0454	0.0174	0.0341
KTK	0.0418	0.0461	0.0170	0.0350	0.0394	0.0466	0.0111	0.0324	0.0406	0.0464	0.0140	0.0337
MDP	0.0351	0.0389	0.0209	0.0316	0.0338	0.0400	0.0112	0.0283	0.0344	0.0394	0.0160	0.0300
MHR	0.0337	0.0416	0.0139	0.0297	0.0344	0.0506	0.0094	0.0315	0.0340	0.0461	0.0116	0.0306
ORS	0.0232	0.0357	0.0139	0.0243	0.0168	0.0370	0.0081	0.0206	0.0200	0.0364	0.0110	0.0224
PNB	0.0157	0.0184	0.0075	0.0139	0.0252	0.0310	0.0084	0.0215	0.0204	0.0247	0.0079	0.0177
RAJ	0.0120	0.0187	0.0101	0.0136	0.0205	0.0285	0.0079	0.0190	0.0162	0.0236	0.0090	0.0163
TND	0.0550	0.0456	0.0259	0.0422	0.0472	0.0504	0.0124	0.0367	0.0511	0.0480	0.0192	0.0394
UTP	0.0197	0.0159	0.0025	0.0127	0.0326	0.0356	0.0129	0.0270	0.0262	0.0258	0.0077	0.0199
WBN	0.0284	0.0222	0.0179	0.0228	0.0313	0.0395	0.0113	0.0274	0.0298	0.0308	0.0146	0.0251
Mean	0.0281	0.0286	0.0154	0.0241	0.0290	0.0367	0.0094	0.0250	0.0286	0.0326	0.0124	0.0245

highly significantly different among the states (for rural regions, $F_{16, 32 \text{ d.f.}} = 9.894$, with a p-value $= 3.01 \times 10^{-8}$; and for urban regions, $F_{16, 32 \text{ d.f.}} = 6.057$, with a p-value $= 7.96 \times 10^{-6}$) as also among the three rounds (for rural regions, $F_{2, 32 \text{ d.f.}} = 28.998$, with a p-value $= 6.53 \times 10^{-8}$; and for urban regions, $F_{2, 32 \text{ d.f.}} = 103.628$, with a p-value $= 1.05 \times 10^{-14}$). However, on an average, the extents of inequalities among rural and urban regions were comparable ($F_{1,\ 32\ d.f.}$ = 2.839, with a p-value = 0.102). Temporally, the inequalities portrayed an inverted-U pattern. Gravity of the situation on calorie inequalities in south Indian states (like Tamil Nadu, Kerala and Karnataka) was alarming whereas, on the other extreme, the same in certain north-Indian hilly states (like Himachal Pradesh and Jammu & Kashmir) was quite manageable.

5.2. Canonical Correlation Analysis

This part of the analysis aimed primarily at examining whether inclusion of the (four) demographic variables in conjunction with the (eleven) variables of physical & social health infrastructure was justified or not. As per our computations (Table 5.2.1), the first (*i.e.,* the highest) ordered canonical correlation coefficient (= 0.8837, associated with 140 d.f.) between the two groups of variables was tested (through *Wilks'* λ) to be highly significant (p-value ≈ 0). However, the other lower-ordered canonical correlates failed to show statistical significance. The

Table 5.2.1. Canonical Correlation Coefficients (Rc) of Different Orders between the Two Groups of Variables, and Testing for their Statistical Significance

Dimension	Computed Value of R_c	Wilk's Λ for R_c	F-Value for Λ	DF_1	DF_2	p-value for F
1	0.8837^{***}	0.0882	2.820	44	140	<0.0001
2	0.6450^{NS}	0.4025	1.321	30	109	0.1515
3	0.4657^{NS}	0.6892	0.864	18	76	0.6217
4	0.3463^{NS}	0.8801	0.664	8	39	0.7193

Table 5.2.2. Redundancy Measures for the X-Set (*i.e.,* Endogenous) and Y-Set (*i.e.,* Exogenous) of Variables

Order (i)	R_{dx_j}	R_{dy_j}
1	0.4204	0.2006
2	0.0465	0.0770
3	0.0303	0.0338
4	0.0252	0.0.105
Total	R_{dx} = 0.5224	R_{dy} = 0.3220

redundancy measure (= 0.322) of the first group of variables, given the information on the second group (Table 5.2.2), implied that even in the presence of the latter group, more than two-third of the information contained in the former group remained unsqueezed, thereby providing a strong evidence in the favour of including demographic variables alongwith the other infrastructural variables of health, as in the next section.

5.3. Chief Determinants of Health Status among Major Indian States

At each of the three points in time under study, examination of the chief determinants of health status was made separately through the usual factor analysis approach (based on the codes of ‘FAiR’ package), whereas a pooled examination over all the three points (in panel-data framework) was made through time-series factor analysis approach (based on the codes of ‘tsfa’ package), as briefly discussed below:

5.3.1. Point in time: 1999-00 (≡ 55th Round of NSSO)

For the year 1999-00, the compiled information on 16 variables for each of the 17 states has been given in Table 5.3.1.1. These data were then subjected to the factor analysis approach. The *scree plot* (showing a graphical behavior between component number and eigen values of the components) provided an indication that optimum number of factors which need be extracted is *six,* because of the simple reason that the eigen values associated with rest of the components

Table 5.3.1.1. Information on Different Indicators of Health Status among Major States of India: 1999-00

State	Variable															
	BRRT	DTRT	IMRT	LEBR	NHPK	NBPL	SBPK	PHPK	CHPK	DCPL	PRPL	ANPL	LVPL	NRPD	NAPD	PCIN
ANP	44.8	122.0	15.4	63.0	1.14	92.82	0.30	0.04	0.01	38.86	1.79	24.22	3.78	0.04	0.09	18.53
ASM	37.17	104.2	13.3	57.6	0.34	48.33	0.56	0.17	0.04	54.41	2.71	23.05	2.24	0.03	0.04	13.63
BHR	31.3	113.6	16.1	60.0	0.35	35.94	1.94	0.22	0.02	39.82	1.54	14.58	3.10	0.03	0.05	7.19
GUJ	39.7	133.3	16.1	63.1	1.29	127.74	1.13	0.13	0.03	64.81	1.74	21.96	3.03	0.75	0.79	21.05
HAR	37.2	133.3	14.9	64.8	0.18	35.16	2.78	0.77	0.14	5.16	4.16	21.4	1.66	0.01	0.01	26.94
HMP	45.2	138.9	16.7	65.7	0.15	102.95	0.18	0.03	0.01	3.46	4.88	64.33	11.47	0.33	0.64	25.09
JNK	51.0	161.3	19.2	65.7	0.02	21.01	0.24	0.04	0.01	64.20	0.73	10.86	3.88	0.04	0.07	14.08
KRL	55.9	156.3	71.4	73.4	0.54	314.79	0.65	0.16	0.01	92.18	3.21	28.35	5.40	0.08	0.07	22.69
KT	45.	12	17.	64.	0.1	73.	0.	0.1	0.0	110	1.9	26.	4.3	0.4	0.3	19.

K	5	8.2	5	2	5	99	99	9	3	.50	0	31	9	7	6	75
MDP	32.1	97.1	11.4	56.5	0.12	30.72	1.61	0.22	0.06	29.50	4.60	40.65	3.22	0.02	0.03	12.63
MHR	47.8	133.3	20.8	66.0	1.12	104.37	0.61	0.10	0.02	81.42	2.31	18.37	4.04	0.07	0.11	25.56
ORS	41.2	95.2	10.4	57.9	0.20	33.04	1.37	0.34	0.04	38.64	4.79	20.25	3.22	0.03	0.09	11.66
PNB	46.5	135.1	19.2	68.2	0.44	62.41	2.88	0.92	0.18	131.52	2.68	27.21	6.10	0.02	0.03	29.19
RAJ	32.1	117.6	12.7	60.6	0.03	31.59	0.33	0.06	0.01	35.83	4.27	28.39	3.69	0.66	0.15	14.71
TND	52.1	126.6	19.6	64.9	0.31	79.04	0.04	0.04	0.01	102.78	2.23	23.25	7.59	0.01	0.24	23.02
UTP	30.5	97.1	12.0	58.5	0.31	29.11	0.57	0.08	0.04	26.14	0.57	19.84	5.64	0.01	0.14	11.02
WBN	48.5	142.9	19.6	63.8	0.45	68.84	0.83	0.23	0.03	62.45	1.56	21.16	3.98	0.07	0.07	17.82

Table 5.3.1.2. Determinants of Health Status in India: Results of Factor Analysis: 1999-00

Variable	Loadings					
	Factor-1	Factor-2	Factor-3	Factor-4	Factor-5	Factor-6
BRRT	***0.769***	-0.158	0.082	-0.222	0.085	0.036
DTRT	***1.018***	-0.022	-0.174	0.190	0.003	-0.198
LEBR	***0.898***	0.121	0.009	0.043	0.242	-0.055
DCPL	***0.504***	0.154	-0.271	0.093	0.110	0.018
PCIN	***0.626***	0.422	0.340	0.015	-0.094	0.249
SBPK	-0.109	***0.928***	-0.120	0.009	0.036	0.018
PHPK	0.118	***0.977***	-0.023	-0.063	-0.036	-0.038
CHPK	0.122	***0.962***	0.008	-0.046	-0.135	-0.013
PRPL	-0.323	0.307	***0.629***	0.073	0.238	-0.192
ANPL	-0.127	-0.034	***0.927***	0.026	0.074	-0.069
LVPL	0.391	-0.268	***0.742***	-0.164	-0.136	-0.124
NRPD	0.092	-0.048	-0.095	***1.045***	0.011	-0.107
NAPD	0.059	-0.167	0.333	***0.578***	-0.110	0.217
IMRT	0.340	-0.074	-0.034	-0.050	***0.833***	-0.094
NBPL	0.179	-0.103	0.138	0.031	***0.798***	0.241
NHPK	-0.155	-0.031	-0.185	-0.056	0.085	***1.042***
Proportion of Variance Explained	0.224	0.200	0.139	0.098	0.096	0.086
Cumulative Variance Explained	0.224	0.423	0.562	0.660	0.756	0.842

were less than (the standard norm of) unity. Therefore, the subsequent analysis was carried out by taking the number of factors to be extracted equaling six.

The computed values of *loadings* on the factors extracted (with *promax oblique* rotation of the axes) have been presented in the Table 5.3.1.2. In fact, these loadings are measures of association of the study variables on the factors extracted. A glance at the table clearly indicates that the 6 factors taken together were capable of explaining as high as 84.2 percent of the variance in the available data set. In this percentage, the first factor, which was constituted by five variables (*viz.,* birth rate, death rate, life expectancy at birth, number of doctors per lakh of population, and per capita income), was capable of explaining variance to the tune of 22.4 percent. Thus, the most important factor during the year 1999-00 was dominated by the usual demographic (endogenous) variables. The next important (*i.e.,* the second) factor consisted of the number of sub-centers per 100 sq. km, number of primary health centers per 100 sq. km, and number of community health centers per 100 sq. km. Thus, broadly speaking, the factor was composed of the variables pertaining to physical infrastructure of health. Further, health manpower variables (such as, number of pharmacists per lakh of population, number of auxiliary nursing midwives per lakh of population, and number of lady health visitors per lakh of population) constituted the third factor, whereas the variables like number of nurses per doctor and number of health assistants per doctor, constituted the fourth factor. And, finally, the fifth and the sixth factors were found to be consisting of a mixture of demographic (*viz.,* infant mortality rate) and physical infrastructure of health variables (*viz.,* number of hospital beds per lakh of population and number of hospitals per lakh of population).

5.3.2. Point in time: 2004-05 (≡ 61st Round of NSSO)

For the second point in time (*i.e.,* 2004-05, comparable with the time-frame of the 61st Round of the NSSO), basic data on the study variables are given in Table 5.3.2.1. Here again, the scree plot indicated the optimum number of factors to be extracted to be six. Results from the corresponding factor analysis have been given in Table 5.3.2.2. As per the table, the most significant factor (explaining 22.4 percent, out of the total explained variance of 89.0 percent) happened to be constituted by six variables, *viz.,* number of hospital beds per lakh of population; number of auxiliary nursing midwives per lakh of population; number of lady health visitors per lakh of population; number of nurses per doctor; number of assistants per doctor; and per capita income. The second factor consisted of number of sub-centers per 100 sq.km; number of primary health centers per 100 sq. km; and number of community health centers per 100 sq. km. The factor next in importance was constituted by the demographic variables, *viz.,* birth rate; death rate; and life expectancy at birth. Thus, during this point in time, the variables pertaining to health manpower, physical health infrastructure, and demographic traits turned out to be the

Table 5.3.2.1 Information on Different Indicators of Health Status among Major States of India: 2004-05

State	Variable															
	BRRT	DTRT	IMRT	LEBR	NHPK	NBPL	SBPK	PHPK	CHPK	DCPL	PRPL	ANPL	LVPL	NRPD	NAPD	PCIN
ANP	52.4	137.0	17.5	63.5	0.13	43.19	0.37	0.04	0.01	43.58	42.70	25.25	4.25	2.43	0.10	24.46
ASM	40.0	114.9	14.7	58.1	0.13	10.57	1.07	0.17	0.04	56.72	8.56	21.28	2.07	0.64	0.04	15.96
BHR	42.0	123.5	16.4	60.7	0.11	3.34	2.39	0.21	0.04	39.09	4.59	14.12	3.01	0.25	0.08	7.41
GUJ	47.6	140.8	18.5	63.6	0.26	64.50	1.13	0.17	0.04	70.62	38.54	16.63	2.88	2.24	0.63	31.95
HAR	47.6	149.3	16.7	65.3	0.32	31.40	3.21	0.73	0.15	6.05	8.19	19.97	1.94	0.41	0.01	36.47
HMP	75.2	144.9	20.4	66.2	0.25	119.72	0.18	0.06	0.02	8.89	44.18	48.23	9.86	5.72	0.45	32.79
JNK	69.9	181.8	20.0	66.2	0.03	29.83	0.10	0.03	0.02	77.05	10.15	17.79	3.59	0.77	0.07	15.84
KRL	67.6	156.3	71.4	73.5	0.64	87.50	0.77	0.22	0.05	115.76	23.21	29.60	4.97	1.91	0.03	32.08
KTK	55.9	140.8	20.0	64.7	0.45	76.03	0.87	0.15	0.02	122.27	128.06	21.11	3.58	6.44	0.24	25.42
MDP	45.5	111.1	13.2	57.1	0.11	27.24	1.83	0.18	0.05	31.61	2.125	25.45	3.28	1.35	0.04	14.45
MHR	54.9	149.3	27.8	66.4	0.22	44.72	0.58	0.10	0.02	93.44	96.90	16.51	4.45	1.68	0.09	33.77
ORS	61.3	105.3	13.3	58.7	0.30	34.89	1.69	0.31	0.11	38.75	31.35	26.20	3.01	2.27	0.06	15.88
PNB	58.8	149.3	22.7	68.6	0.49	43.02	4.03	0.86	0.20	135.41	137.61	21.33	5.69	0.87	0.03	33.19
RAJ	42.0	142.9	14.7	61.3	0.13	34.90	0.33	0.05	0.01	37.56	29.82	23.81	3.03	2.36	0.12	18.06
TND	62.5	135.1	27.0	65.4	0.69	116.01	0.04	0.02	0.01	110.34	153.09	20.86	6.29	6.95	0.18	28.44
UTP	37.7	114.9	13.7	59.2	0.38	18.15	0.06	0.10	0.01	26.60	16.93	1.41	4.10	0.24	0.10	12.39
WBN	79.4	156.3	26.4	64.1	0.46	64.48	0.83	0.23	0.02	63.28	106.11	17.37	2.10	0.94	0.04	22.22

Table 5.3.2.2. Determinants of Health Status in India: Results of Factor Analysis: 2004-05

Variable	Loadings					
	Factor-1	Factor-2	Factor-3	Factor-4	Factor-5	Factor-6

NBPL	***0.671***	-0.161	0.041	0.413	-0.044	0.086
ANPL	***1.121***	0.175	-0.140	-0.388	-0.118	0.188
LVPL	***0.764***	-0.025	-0.062	0.036	-0.012	0.046
NRPD	***0.718***	-0.222	-0.222	0.165	0.257	-0.166
NAPD	***0.630***	-0.145	0.029	-0.176	0.023	-0.278
PCIN	***0.438***	0.371	0.354	0.133	-0.019	0.031
SBPK	0.005	***0.973***	-0.136	-0.104	0.115	-0.077
PHPK	-0.135	***0.983***	0.079	0.211	-0.063	-0.115
CHPK	0.035	***0.998***	-0.075	0.041	0.032	-0.037
BRRT	0.291	-0.069	***0.512***	0.123	-0.077	0.049
DTRT	-0.244	-0.111	***1.241***	-0.288	0.022	-0.090
LEBR	0.106	0.078	***0.618***	0.068	0.121	0.368
NHPK	-0.057	0.117	-0.245	***1.077***	0.010	0.288
DCPL	-0.052	0.009	0.044	-0.165	***1.043***	0.290
PRPL	0.062	0.112	0.091	0.290	***0.609***	-0.283
IMRT	0.091	-0.183	-0.001	0.290	0.079	***0.920***
Proportion of Variance Explained	0.224	0.204	0.155	0.120	0.099	0.088
Cumulative Variance Explained	0.224	0.428	0.583	0.703	0.802	0.890

significant determinants of health status. Rests of the variables were found to have played relatively less significant role towards explaining the extent of variance in the data set.

5.3.3. Point in time: 2011-12 (≡ 68th Round of NSSO)

The basic information on different indicators of health status for the third point in time (*i.e.,* 2011-12, which had a close comparability with the 68th Round of NSSO) is presented in Table 5.3.3.1. Results from factor analysis as applied to these data have been given in Table 5.3.3.2.

Table 5.3.3.1 Information on Different Indicators of Health Status among Major States of India: 2011-12

State	**Variable**															
	BRRT	**DTRT**	**IMRT**	**LEBR**	**NHPK**	**NBPL**	**SBPK**	**PHPK**	**CHPK**	**DCPL**	**PRPL**	**ANPL**	**LVPL**	**NRPD**	**NAPD**	**PCIN**
ANP	54.6	133.3	20.4	64.2	0.17	45.42	4.55	0.57	0.06	74.42	52.47	33.74	4.16	2.19	0.06	29.57
ASM	42.4	116.3	16.4	59.0	0.20	24.84	5.85	1.08	0.14	62.30	7.92	30.09	1.94	0.77	0.03	18.77
BHR	35.1	137.0	19.2	61.3	1.82	22.16	9.41	1.89	0.07	36.68	4.10	10.05	1.10	0.25	0.03	11.02

GUJ	44.8	145.0	20.8	64.1	0.19	48.81	3.71	0.55	0.14	78.27	35.31	19.07	2.75	1.90	0.58	40.91
HAR	44.1	144.9	19.6	66.1	0.35	31.20	16.45	0.99	0.21	16.36	28.71	25.98	2.24	0.38	0.01	48.64
HMP	58.1	135.1	22.2	66.9	0.26	117.52	3.72	0.81	0.13	18.22	41.60	43.84	2.23	2.07	0.04	42.37
JNK	53.8	172.4	22.2	66.9	0.04	32.11	0.86	0.17	0.04	91.50	17.64	19.68	1.14	7.29	0.17	17.7
KRL	68.0	151.5	83.3	73.9	0.99	94.15	11.77	1.79	0.59	144.82	53.07	24.00	3.73	1.78	0.40	43.71
KTK	51.3	135.1	24.4	65.4	0.48	105.80	4.25	1.14	0.17	144.94	131.97	19.57	2.60	1.56	0.14	32.72
MDP	36.1	116.3	14.9	58.0	0.15	40.04	2.88	0.37	0.11	37.31	1.93	23.61	0.67	1.11	0.01	14.65
MHR	56.8	151.5	32.3	67.2	0.58	45.16	3.44	0.59	0.12	124.48	95.94	26.04	6.14	1.65	0.12	39.37
ORS	47.6	111.1	15.4	59.6	1.26	38.36	4.94	0.94	0.17	40.54	34.57	20.44	2.24	2.46	0.04	22.08
PNB	58.8	138.9	26.3	69.4	0.46	38.83	5.86	0.78	0.26	140.53	129.03	25.361	2.98	0.77	0.01	41.03
RAJ	36.8	147.1	16.9	61.9	0.14	47.65	3.20	0.44	0.11	42.37	27.06	27.52	3.08	2.24	0.12	22.45
TND	61.3	135.1	35.7	66.2	0.45	66.38	6.69	0.98	0.20	122.11	213.74	18.05	2.56	6.56	0.06	34.66
UTP	34.8	119.1	15.9	59.9	0.36	28.77	8.52	1.53	0.21	29.57	15.45	1.14	0.21	0.24	0.09	14.74
WBN	58.1	161.3	30.3	65.0	0.33	60.73	11.67	1.04	0.38	65.29	99.41	19.14	1.24	0.84	0.02	27.99

Table 5.3.3.2. Determinants of Health Status in India: Results of Factor Analysis: 2011-12

Variable	Loadings					
	Factor-1	Factor-2	Factor-3	Factor-4	Factor-5	Factor-6
BRRT	***0.563***	0.181	0.444	-0.233	0.130	-0.017
NBPL	***0.595***	0.076	0.157	0.048	-0.186	-0.035
ANPL	***1.275***	-0.233	-0.430	-0.327	-0.083	0.006
LVPL	***0.569***	-0.154	0.178	0.198	-0.092	0.076
LEBR	***0.413***	0.225	0.221	0.092	0.389	0.205
IMRT	0.331	***0.727***	-0.112	0.173	0.089	-0.133
NHPK	-0.263	***0.545***	0.025	-0.039	-0.167	-0.061
SBPK	-0.009	***0.839***	-0.070	-0.243	0.233	0.707
PHPK	-0.256	***0.876***	0.024	-0.046	-0.214	0.144
CHPK	0.183	***0.841***	-0.005	0.068	-0.003	0.178
DCPL	-0.085	0.021	***0.742***	0.160	-0.040	-0.215
PRPL	-0.090	-0.082	***1.252***	-0.298	-0.123	0.166
NRPD	-0.114	-0.337	***0.328***	-0.092	0.299	-0.424
NAPD	-0.197	-0.060	-0.286	***1.143***	0.044	0.009

DTRT	-0.072	-0.081	-0.139	0.044	***1.118***	0.089
PCIN	0.645	-0.016	0.311	0.283	-0.022	***0.695***
Proportion of Variance Explained	0.222	0.206	0.183	0.114	0.107	0.085
Cumulative Variance Explained	0.222	0.429	0.612	0.726	0.833	0.918

Scree plot for the analysis has, once again, provided an indication towards the acceptance of six factors for extraction. As per the results (Table 5.3.3.2), nearly one-fourth (22.2 percent) of the total explained variance (of 91.8 percent) was attributable to the most significant (*i.e.,* the first) factor, which happened to be a mixture of usual demographic indicators (like, birth rate and life expectancy at birth), physical health infrastructure (like, number of hospital beds per lakh of population), and health manpower statistics (such as, number of auxiliary nursing midwives per lakh of population and number of lady health visitors per lakh of population). Notably, the next most-significant factor (associated with variance explanation of nearly 21 percent) was broadly made up of physical health infrastructure variables (such as, number of hospitals per 100 sq.km, number of sub-centers per lakh of population, number of primary health centers per lakh of population, and number of community health centers per lakh of population). The remaining four factors were far from being explicit in nature, as these involved a mixture of the types of dimensions.

5.3.4. Pooled Analysis

Next, in order to squeeze out the overall picture on major determinants of health, the information at all the three points in time (in panel data frame work) was subjected to time series factor analysis. The analysis was capable of extracting a totality of *five* factors, which together could explain 67.4 percent of the variance in the data set (Table 5.3.4.1).

As regards constitution of the factors, the first factor (which could explain 18.1 percent of the variance) was constituted by three variables *viz.,* number of sub-centers per 100 sq km; number of primary health centers per 100 sq km; and number of community health centers per 100 sq km. Clearly, each of the constituent variables of the most important factor referred to the physical infrastructure of health. The next important factor (having accounted for 16.7 percent of the variance explained) was composed of four variables, *viz.,* infant mortality rate; life expectancy at birth; number of hospital beds per lakh of population; and number of doctors per lakh of population. The factor, obviously, happened to be a synthesis of physical & social health infrastructure, as also demographic variables. The third factor (capable of explaining 12.6 percent of the variance) was made up of two variables of social infrastructure: number of pharmacists per lakh of population; and number of nurses per doctor. Similarly, the fourth factor (responsible for explaining 11.3 percent of the variance), too, consisted of another couple of

Table 5.3.4.1. Determinants of Health Status in India: Pooled Results of Time Series Factor Analysis

Variable	Loadings				
	Factor-1	**Factor-2**	**Factor-3**	**Factor-4**	**Factor-5**
SBPK	***0.971***	-0.104	0.001	0.044	0.060
PHPK	***0.873***	0.067	0.009	-0.076	-0.061
CHPK	***0.841***	0.143	0.073	0.056	-0.045
IMRT	0.120	***0.830***	-0.130	-0.050	0.066
LEBR	0.052	***0.795***	-0.099	0.054	0.364
NBPL	-0.192	***0.638***	-0.096	0.234	-0.081
DCPL	-0.126	***0.640***	0.413	-0.296	-0.084
PRPL	0.086	-0.045	***1.071***	-0.062	-0.151
NRPD	-0.121	-0.183	***0.658***	0.070	0.094
ANPL	0.144	-0.153	-0.061	***0.983***	-0.130
LVPL	-0.328	0.263	0.025	***0.587***	-0.154
DTRT	-0.016	0.241	-0.132	-0.209	***1.001***
BRRT	-0.073	0.276	0.358	0.072	0.315
NHPK	0.174	0.414	-0.053	-0.193	-0.193
NAPD	-0.093	0.017	-0.097	0.320	0.097
PCIN	0.462	0.262	0.251	0.379	0.092
Prop. of Variance Explained	**0.181**	**0.167**	**0.126**	**0.113**	**0.087**
Cum. Prop. of Variance Explained	**0.181**	**0.348**	**0.474**	**0.587**	**0.674**

variables of social infrastructure, *viz.,* number of auxiliary nursing midwives per lakh of population; and number of lady health visitors per lakh of population. And, the last significant factor (accounting for 8.7 percent of the variance explained) consisted of the lone demographic variable – death rate. Notably, as per the results of the pooled analysis, rest of the four variables (*viz.,* birth rate; number of hospitals per 100 sq km; number of assistants per doctor; and per capita income), in the presence of the rest of the 12 variables, failed to show their importance while determining the health status of a state.

The analysis has thus provided us with an evidence that relative significance of different parameters of health status among the Indian states has not remained time invariant, but has instead undergone a drastic reshuffling during the study span. As per the pooled analysis, the most important dimension of health among the major Indian states is composed of the parameters of physical health infrastructure, followed by those of social health infrastructure.

5.4. Relative Positioning of the Major Indian States – Construction of the Composite Index

In order to examine the relative positioning of the major Indian states, as also to study temporal shifts, if any, in the positioning at each of the points in time (as also over the entire study period taken together), the composite index of health status was constructed through the methodology as outlined in Section 4.3 above (Table 5.4.1). A glance at the table shows that in the year 1999-00, Punjab (with a value of 4.57 for the index) occupied the top position, followed next by Kerala

Table 5.4.1. Composite Index of Health Status among the Major Indian States

State	1999-00		2004-05		2011-12		Pooled	
	Composite Index	Rank	Composite Index	Rank	Composite Index	Rank	Composite Index	Rank
ANP	3.246	11	2.334	12	2.666	9	2.659	9
ASM	2.942	16	1.978	16	2.315	15	2.064	14
BHR	2.958	15	2.027	15	2.340	14	1.914	15
GUJ	3.714	5	2.659	7	2.630	10	2.827	8
HAR	3.937	3	2.859	6	2.739	8	2.125	12
HMP	3.885	4	3.366	2	2.933	7	2.996	7
JNK	3.340	10	2.339	11	2.368	12	2.612	10
KRL	4.274	2	3.230	3	4.076	1	4.436	1
KTK	3.622	7	2.861	5	3.001	5	3.751	3
MDP	3.042	14	2.147	14	1.909	17	1.892	16
MHR	3.637	6	2.534	9	3.029	3	3.379	5
ORS	3.084	12	2.444	10	2.378	11	2.104	13
PNB	4.572	1	3.566	1	3.027	4	3.728	4
RAJ	3.080	13	2.181	13	2.360	13	2.265	11
TND	3.508	9	3.000	4	3.194	2	4.036	2
UTP	2.662	17	1.724	17	2.007	16	1.766	17
WBN	3.527	8	2.571	8	2.994	6	3.232	6

(4.27), Haryana (3.94), Himachal Pradesh (3.88), and Gujarat (3.71). On the other extreme, the bottom positions were occupied by Uttar Pradesh (2.66) preceded by Assam (2.94) and Bihar (2.96). In the year 2004-05, too, Punjab (having a value of the index equaling 3.57) continued to maintain its top position, while Himachal Pradesh (3.37) improved its position to occupy the second slot, followed then by Kerala (3.23). Notably, the state of Tamil Nadu (3.00), which happened to be at ninth position during 1999-00 underwent a drastic improvement and occupied the fourth position during 2004-05. While, the bottom slots continued to be occupied by the states like Uttar Pradesh (1.72), closely preceded by Assam (1.99) and Bihar (2.03). However, during 2011-12, the state of Kerala (4.27) was observed to have occupied the top position, whereas Tamil Nadu (3.19) experienced a further improvement in its position to have come at the second slot. Our findings are in fair agreement with those due to Kurian (2000) according to whom, even if a state is at a relatively lower level of per capita income, can yet enjoy a comparatively higher level of social development. Incidentally, the state of Punjab (associated with a value of 3.03 for the composite index) has lately slipped from the first rank to the fourth rank which, indeed, is a matter of concern for the state. On the other hand, Maharashtra, which was as low as at the 9^{th} position (during 2004-05) has undergone a perceptible improvement to have occupied the 3^{rd} position (during 2011-12). However, the states like Uttar Pradesh, Madhya Pradesh, Bihar, Assam and Rajasthan have continued to remain at relatively lower positions in terms of health status in a fairly stable manner.

The overall picture of the relative rankings of the states, as obtained through values of the composite index computed from the output of the time series factor analysis (Table 5.4.1) had a close similarity with the picture in respect of the analysis for 2011-12 (Table 5.3.3.2). On the whole, Kerala was ranked number one state (with a score of 4.44), followed next by Tamil Nadu (4.04), Karnataka (3.75), Punjab (3.73) and then by Maharashtra (3.38). On the other extreme, the states like Uttar Pradesh (1.77), Madhya Pradesh (1.89), Bihar (1.91), Assam (2.06) and Odisha (2.10) have occupied the bottom positions on health traits.

5.5. Examining Interlinkages among Health Status, Calorie Inequalities and Per Capita Income among the Major Indian States

In order to examine the nexus, if any, among calorie inequalities, health status, and the level of income among the major Indian states, we have sought the help of simple correlation analysis. In fact, the correlation coefficients were obtained indirectly through the simple linear regression analyses (among the three yardsticks, *viz.,* health status, calorie inequalities and per capita income) in the *panel data framework,* with due application of *Hausman's (1978) test,* so as to make a judicious choice between *fixed effects* and Nerlove's version of *random effects modeling*.

Table 5.5.1. Correlation Analysis among Composite Index of Health (CMIN), Index of Calorie Inequality (FGT2) and Per Capita Income (PCIN)

Pair of Yardsticks	Hausman's test		Correlation Coefficient		
	χ2-statistic	p-value	r	d.f.	p-value
CMIN & FGT2	0.3731[NS]	0.5413	-0.3049[*]	49	0.0298
CMIN & PCIN	0.6372[NS]	0.4247	0.7720[***]	49	< 0.0001
FGT2 & PCIN	0.6293[NS]	0.4276	-0.2512[NS]	49	0.0754

NS: Non-significant; *: Significant at 5% probability level; ***: Significant at 0.1% probability level;

In each of the three pairs, non-significance of the χ^2-statistic for Hausman's test (Table 5.5.1) suggested that the more versatile *random effects modeling* be preferred. As per the modeling, association between the composite index of health status (CMIN) and FGT(2) measure of the inequalities was observed to be indirect (r = -0.3049) and statistically significant (p = 0.0298). Further, there was a feeble indication of an indirect association between the measure of inequalities and per capita income (r = -0.2512; p = 0.0754). However, the association between the composite index of health and per capita income was direct (r = 0.7720) and very robust (p-value < 0.0001). Thus the states with better health status have shown a very strong tendency to be associated with higher income level and, that; such states would expectedly have less severe incidence of calorie inequalities.

5.6. Conclusion and Policy Implications

As per the results, we have seen that within each of rural and urban regions, the averaged inequalities were highly significantly different among the states as also among the three rounds of NSSO. However, on an average, the extents of inequalities among rural and urban regions were comparable. The chief determinants of health status were observed to have undergone voluminous reshuffling during the study span, from usual demographic indicators to those of physical and social health infrastructure. Further, the states with better health status showed a very strong tendency to be relatively richer and low in the extent of calorie inequalities. Thus, as a policy measure, there is a dire need for shifting priorities in favour of investment on both physical and social health infrastructure, particularly in laggard states and in those states which have undergone a rapid slippage in their ranking. If the state alone cannot shoulder the burden of increased expenditure on this important economic activity, then *public-private-partnership model* needs be propagated. Improved health conditions would expectedly enhance incomes of the people which, in turn, might bring down the severity of inequalities in calorie intake.

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