Construction of an Indian States Health Achievement Index and Equality Adjusted Health Achievement Index (ISHAI and ISHAIEQ)

Prepared by Sylvestre Gaudin*

This draft: November 12, 2008**

*Email: Sylvestre.gaudin@oberlin.edu

** The first complete draft dated June 29, 2008 was prepared for Abdo Yazbeck under a consulting contract for the World Bank.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. MOTIVATION AND PRELIMINARY CONSIDERATIONS

Data from the National Family and Health Survey of India (NFHS) have generated a large amount of output in terms of health indicators. While it is interesting to compare states and rural-urban areas along each dimension, one cannot get a sense of the overall picture in each state and compare health achievement between states by looking at a single indicator. While some aspects of achievement will be positively correlated with each other (for example better facilities allow dispensation of preventive measures as well as more treatment overall), substitution effects (improvement in one dimension at the expense of another) will likely take place because of limited resources.

In addition to overall achievement, one would want to be able to get a sense of its distribution by income class; in particular, whether states that have performed well in terms of overall health have managed to reach the poorest segment of their population. Asset data from the NFHS was used to categorize households into quintiles and to calculate means by quintiles, adding more tables of figures. Instead of looking at the data in quintiles, however, one can construct achievement indices using Wagstaff's methodology (Wagstaff, 2002; Gaudin and Yazbeck, 2006). The Wagstaff Index takes account of mean achievement in each wealth quintile and changes the weight given to each quintile depending on the degree of inequality aversion chosen (v). Value judgments on the level of inequality aversion need to be made before the six numbers (means for each quintile and overall mean) can be reduced to one number. In effect, it is practical to present Wagstaff indices for two or three different levels of inequality aversion.

With multiple dimensions of health and distributionally-sensitive measures for each indicator, it becomes difficult to look at the data and get a meaningful picture of the overall situation. In order to quickly identify areas that need most attention, one needs to find some way of condensing the data. Here, I construct a composite index that incorporates achievement along different dimensions of preventive health, outcomes, and treatment. The index can be calculated for different levels of inequality aversion, making explicit value judgments on the relative importance of bottom versus top quintiles. While such an index cannot be used to make policy (to do so, one needs to examine performance at the level of one indicator or one group of similar indicators), it can help identify overall success or failure at first glance, motivating the analyst to go beyond the index and scrutinize the source of the ranking.

Two methods are proposed to generate the index, both inspired by the United Nations Human Development Index and existing variants from the literature (see for example Desai, 1991; Cortinovis, Vela, and Ndiku, 1993; Cahill and Sanchez, 2001; Biswas and Caliendo, 2002). One of the indices utilizes fixed arbitrary weights on selected indicators judged to be most important in measuring health sector performance; the other uses the principal component method to incorporate a larger set of indicators and assign weight according to the contribution of each indicator to an overall variance revealed by the data itself. Both can be easily transformed to incorporate dimensions of inequality simply by replacing state-level means by Wagstaff indices for different levels of inequality aversion.

There are advantages and disadvantages to each method. The first method resembles that of the Human Development Index. It has the advantage of being simple, explicit, and easily reproducible across countries and time. One disadvantage is that the set of indicators on which it relies is necessarily small and, consequently, improvements in excluded variables are ignored. In

addition, both because of the limited number of indicators chosen and the arbitrariness of weights, the index may be subject to criticism from states scoring low, shifting the debate to missing dimension and issues of index construction rather than the need for overall improvement.[1]

The principal components method has the advantage of reducing arbitrariness in terms of weights assigned to different dimensions of wealth and allows the inclusion of a larger set of indicators. One important aspect of the principal component analysis that is often ignored is that the methods assign weights according to the importance of the indicator in explaining the variance between states. This could be considered an advantage in some cases and a disadvantage in others. If the goal is to emphasize differences between states or if states perform unequally along many important dimensions, the method is good. However, if all the important dimensions of health vary little between states and the variance is mostly explained by some dimensions judged less important in terms of human welfare, it is the unimportant dimension that will drive the ranking. Because of this, it is important to examine the table of weights assigned by the principal components method before interpreting the ranking.

Both methods do take into account issues of diminishing marginal utility. For example an improvement at the high end of immunization (say going from 90 to 95 percent immunization) may hide poor performance at the bottom of the distribution in some other indicator. The good news is that, for most indicators, improved performance at the high end is more difficult than improvement from a low position. In addition, states that perform on the high end in one dimension do not usually rank at the bottom in other dimension. It is important to restate, however, that any index, whether it is constructed using fixed weights or any more advanced statistical procedure will only be a tool to rapidly identify successes, failures, and general trends, not policy.

This paper focuses on the methodology of index construction. Rankings obtained with the fixed weight index for various degrees of inequality aversion are presented in section 4.2; they are compared to results of the principal component index in section 5.2.

2. DATA

Indicators available to construct the index are calculated for all three waves of the National Family and Health Survey of India for the 20 largest states/Union Territories of India. (Wave I data was gathered in 1992-93, Wave II in1998-99 and wave III in 2005-6).[2] Indicators are calculated separately for the full state, rural areas of the state and urban areas of the state giving us three observations per state per NFHS wave when available. Because of the complex survey design of the NFHS, clustering and weights are taken into account to calculate averages and their standard errors. Data is available by wealth quintiles calculated using principal components analysis from a large set of asset data. Principal component analysis is performed

[1] It is also possible that, once the composition of the index is known, the choice of indicators may affect the direction of progress. In this case, one may expect less attention to be given to areas not accounted for in the index).

[2] In 2000, three states were split to form three new states: Jharkhand out of Bihar, Chhatisgarh out of Madhya Pradesh, and Uttaranchal (later Uttarkhand) out of Uttar Pradesh. Uttar Pradesh kept 95 percent of its population but the other two states lost about 25 percent. The three new states are included in the data despite their smaller size in order to reconstitute the three "old" states for comparison over time.

only on the subset considered; i.e. full state quintiles are based on state sample while rural/urban quintiles are based on principal component analysis on the rural/urban sample only.[3]

2.1 Initial data preparation

A first selection of indicators was made so as to eliminate those that a priori would not be used in the index calculation.

a. Indicators that were not available in all three waves of the NFHS were dropped so as to allow comparison over time. To construct an index based on a different data set of later periods, one needs to consider all indicators available and evaluate their quality and relevance.

b. Only three indicators on individual behavior were available for all three waves of the NFHS: exclusive breastfeeding, bottle feeding, and timely complementary feeding. Since these variables captured only a very specific dimension of individual behavior, the individual behavior category was dropped. Timely complementary feeding was retained as an element of prevention likely related to ante-natal care rather than behavior.

c. Redundant indicators were dropped. For example public provision plus private provision added approximately to one in all cases so only public provision was retained. Delivery was broken down into public, private, and home. The base for all of them is the total number of deliveries, the same base as for the attended deliveries indicator. Since private share plus public share made up one hundred percent of attended deliveries, the private share was dropped. Stunting/underweight indicators included mild, mild plus severe, and severe only. Mild was dropped.

d. Subsets of other indicators were dropped when they did not add useful information. In particular, delivery attendance by a trained medical person includes both attendance by doctors and attendance by nurses or trained midwife, and similarly for antenatal care visits; in the absence of data on quality of care by doctors relative to other medically trained professionals, the breakdown was dropped. On the other hand, the breakdown of immunization data into BCG, DPT, and measles was retained as it is possible that one dimension only would capture differences between states better than the combined basic coverage indicator.

e. Finally, indicators on nutrition included different calculation methods, the "old" method based on the National Center for Health Statistics formulas and the "new method" that followed the new WHO standards officially released in April 2006 (based on recommendations of the Multi-center Growth Reference Study). Simple correlation checks between results of the two methods for severe stunting and underweight indicated high correlation (ρ>97). Since the new method could be used to recalculate all nutrition indicators and average base sample sizes were slightly larger for the new method in most cases, the new method was retained.

Remaining indicators were categorized into three main categories, preventative (prevent), outcome (out), and treatment (treat). A fourth dimension to capture the relative strength of the

[3] Indicators by States and rural/urban areas for the three waves of NFHS with their averages by quintile and overall, standard errors, and sample sizes are available in a MS Access data base: IndiaConsolidatedData.mdb. The data set was imported into STATA and tasks were performed to remove information based on small sample sizes and calculate grouped concentration indices, achievement indices, and coefficients of variation. Only data for combined gender was retained for this work.

private sector (public) was created to account for the fact that private sector provision of care is often utilized when the public sector is unable to provide adequate care. Breakdowns between public and private provision were reported for treatment indicators, including delivery care as well as the provision of modern contraceptives.

2.2 Evaluation of data availability and quality

For both methods of calculating the index, it is important to take account of data availability and data quality so as to represent as many states/state areas as possible. Indicators that are calculated with larger sample sizes and are more readily available also provide more reliable estimates; if there are several indicators measuring the same dimension, it is best to use the most reliable one.

Table 1 (a-d) and 2 (a-d) provide a summary assessment of data availability and quality for variables available in the three waves of NFHS. Data availability (Tables 1a-d)) is measured using the number of states and rural/urban areas of states with non-missing data for a given indicator in each NFHS wave. The maximum number of observations per indicator per wave is 60 (20 states: all/rural/urban).[4] Missing data are either due to the fact that a certain dimension was not measured in a given state or year or because the number of observations used to calculate the indicator was too small to make any meaningful inference. Following methodology from the Demographic and Health Survey reports, sample sizes lower than 250 for mortality, 125 for fertility, and 25 for other indicators are considered insufficient and the indicator is reported as missing. Indicators based on sample sizes between 250 and 500 for mortality, between 125 and 250 for fertility, and between 25 and 50 for other indicators are normally given in parentheses as they are "borderline". In tables 1 and 2, the number of borderline cases is indicated in parentheses; each entry x (y) in the first column (Avg) therefore reads as "there are x non missing observation for indicator averages of which y are based on borderline sample sizes". Exceptions were made for treatment and public/private shares of treatment because sample sizes for the treatment indicators are themselves endogenous in the sense that a small sample size could be due to low incidence. Consequently, available data for treatment indicators were only dropped in cases when the corresponding incidence indicator was dropped. The same procedure was utilized for public share of treatment.

Data availability for equality adjusted numbers of the Wagstaff Index (WI) is reported next to data availability for averages. Given that the calculation of WIs relies on estimates per quintile and the same quality norms are imposed for each quintile, data availability and quality is generally lower when equality must be taken into account.

[4] New states formed after 2000 are excluded when checking data availability/quality.

Table 1a. Data Availability: Outcomes

	NFHS wave (Survey years)	I (1993/4)		II (1998/9)		III (2005/6)	
Indic	**Indicator description**	**Avg**	**WI**	**Avg**	**WI**	**Avg**	**WI**
O1.	**Mortality**						
imr	Infant mortality rate	59 (3)	43	58 (3)	40	58 (1)	39
u5mr	Under 5 mortality rate	59 (3)	43	58 (3)	40	58 (1)	39
O2.	**Fertility**						
adofr	Adolescent fertility rate	35 (12)	1	28 (8)	2	51(8)	17
tfr	Total fertility rate	60 (1)	54	60 (2)	53	60 (0)	55
O3.	**Nutrition**[a/]						
undw12_new	Severe and moderate underweight	60 (0)	56	60 (2)	51	60 (0)	56
undw2_new	Severe underweight	60 (0)	56	60 (2)	51	60 (0)	56
stunt12_new	Severe and Moderate stunting	45 (0)	42	60 (2)	51	60 (0)	56
stunt2_new	Severe Stunting	45 (0)	42	60 (2)	51	60 (0)	56
obesity_new	Obesity	41 (0)	40	59 (2)	50	60 (0)	56
O4.	**Prevalence of Disease (child)**						
dia	Prevalence of diarrhea	59 (0)	56	59 (0)	52	60 (0)	56
fev	Prevalence of fever	60 (1)	56	60 (0)	52	60 (0)	56
ari	Prevalence of ARI	59 (1)	56	60 (0)	52	60 (0)	56

[a/] All nutrition indicators are calculated with the new standards based on WHO recommendations

Table 1b. Data Availability: Prevention

	NFHS wave Survey years	I 1993/4		II 1998/9		III 2005/6	
Indic	**Indicator description**	**Avg**	**WI**	**Avg**	**WI**	**Avg**	**WI**
P1.	**Immunization**						
fi	Full Immunization: Basic coverage before 3 years old (BCG, DPT, Measles)	59 (3)	39	57 (4)	40	57 (1)	37
fi_BCG	Full Immunization: BCG	59 (3)	39	55 (4)	39	56 (1)	37
fi_DPT	Full Immunization: DPT	59 (3)	39	57 (4)	40	57 (1)	37
fi_Meas	Full Immunization: measles	59 (3)	39	57 (4)	40	57 (1)	37
ni	No-Immunization	59 (3)	39	49 (2)	36	49 (1)	35
P2.	**Antenatal Care**						
ancv	At least 1 antenatal care visit received from a medically trained person	60 (0)	56	58 (1)	51	59 (0)	55
ancv3	3 or more antenatal care visits	60 (0)	56	60 (1)	52	60 (0)	56
anctt	Tetanus toxoid	60 (0)	56	60 (1)	52	60 (0)	56
P3.	**Fertility and Nutrition**						
mcuse	Use of modern contraceptives	60 (0)	60	60 (0)	60	60 (0)	60
complfeed	Timely complementary feeding	53 (8)	15	49 (9)	11	50 (8)	8

Table 1c. Data Availability: Treatment

	NFHS wave Survey years	I 1993/4		II 1998/9		III 2005/6	
Indic	**Indicator description**	**Avg**	**WI**	**Avg**	**WI**	**Avg**	**WI**
T1.	**Treatment of Children Diseases**						
diat	Treatment of diarrhea	59 (0)	54	59 (0)	52	59 (0)	55
ors	Use of ORS (Oral Rehydration salts, used in the treatment of dehydration often caused by diarrheal or intestinal disease)	59 (0)	54	59 (0)	52	60 (0)	55
fevt	Treatment of fever	60 (0)	56	60 (0)	52	60 (0)	56
arit	Treatment of ARI (Acute Respiratory Infection)	59 (0)	52	58 (0)	52	59 (0)	53
T2.	**Child Delivery**						
attdeliv	Last child delivery was attended by a medically trained person	60 (0)	56	60 (1)	53	59 (0)	55
delhom	Delivery at home	60 (0)	56	59 (1)	53	59 (0)	55

Table 1d. Data Availability: Public Sector Share

	NFHS wave Survey years	I 1993/4		II 1998/9		III 2005/6	
Indic	**Indicator description**	**Avg**	**WI**	**Avg**	**WI**	**Avg**	**WI**
Z1.	**Treatment**						
diapub	Treatment of diarrhea in a public facility	54 (0)	50	58 (0)	52	58 (0)	54
fevpub	Treatment of fever in a public facility	59 (0)	56	60 (0)	52	60 (0)	56
aripub	Treatment of ARI (Acute Respiratory infection) in a public facility	56 (0)	52	59 (0)	52	59 (0)	53
delpub	Delivery in a public health care facility	60 (0)	56	60 (1)	53	60 (0)	56
Z2.	**Prevention**						
mcpub	Use of modern contraceptives: public source	60 (0)	56	60 (0)	57	60 (0)	57

To assess the quality of the data beyond sample sizes, one can look at coefficients of variation (Table 2 a-d). Regular coefficients of variation (standard error divided by mean for each observation) would be misleading here as indicators with low means tend to have higher CVs by construction. For example, when comparing rates of no-immunization, there can be two states with the same sample size but large differences in performance. If one state has a low rate of no-immunization (good performance), while the other has a large rate (bad performance), the low-performing state will appear to have better quality data based on coefficients of variation when in fact it is only because the value of the indicator is higher. Using a standard error relative to the overall India average for a given indicator mitigates this problem. The numbers reported in Table 2 a-d are "modified" coefficients of variation (MCV) thus calculated.[5] MCVs are also

[5] Modified coefficients of variation require that standard errors be calculated in the original data. Standard errors were missing for mortality indicators by rural/urban areas, therefore the average MCV's for mortality indicators

calculated for equality adjusted indicators (WI), in which case it is the simple average of the quintile specific MCVs.[6] In all cases one needs to keep in mind when looking at tables 2 a-d that, when they are based on similar sample sizes, indicators with expected lower values (for example no-immunization) will have higher MCVs than indicators with high values (for example full-immunization).

Table 2a. Data Quality: Modified Coefficients of Variation - Outcomes

	NFHS wave Survey years	**I 1993/4**		**II 1998/9**		**III 2005/6**	
Indic	**Indicator description**	**Avg**	**WI**	**Avg**	**WI**	**Avg**	**WI**
O1.	**Mortality**						
imr	Infant mortality rate [a/]	.05	.11	.06	.13	.07	.16
u5mr	Under 5 mortality rate [a/]	.05	.10	.05	.11	.06	.14
O2.	**Fertility**						
adofr	Adolescent fertility rate	.05	.08	.06	.12	.15	.30
tfr	Total fertility rate	.04	.07	.04	.08	.05	.09
O3.	**Nutrition[b/]**						
undw12_new	Severe and moderate underweight	.05	.09	.07	.12	.06	.11
undw2_new	Severe underweight	.08	.16	.11	.21	.10	.20
stunt12_new	Severe and Moderate stunting	.05	.08	.06	.10	.05	.10
stunt2_new	Severe Stunting	.07	.12	.10	.17	.09	.17
obesity_new	Obesity	.25	.44	.37	.49	.33	.59
O4.	**Prevalence of Disease (child)**						
dia	Prevalence of diarrhea	.12	.23	.10	.18	.14	.26
fev	Prevalence of fever	.08	.16	.08	.14	.12	.21
ari	Prevalence of ARI	.17	.31	.11	.19	.15	.26

[a/] MCVs for mortality indicators are based on 1/3 of the observations as standard errors for rural/urban areas were not calculated.

[b/] All nutrition indicators were recalculated with the new WHO standards

reported in the table are only based on full state data and are therefore expected to be lower than the average MCVs of indicators that include the full state and the separated urban/rural indicators.

[6] Care needs to be taken when looking at MCVs for treatment and public/private share indicators. Although the number of states/state areas with sufficient data was determined using the utilization/incidence sample size, the MCVs are based on their own standard errors. MCV's for those categories will likely be higher since sample sizes are allowed to fall below the minimum of 25.

Table 2b. Data Quality: Modified Coefficients of Variation - Prevention

	NFHS wave Survey years	I 1993/4		II 1998/9		III 2005/6	
Indic	**Indicator description**	**Avg**	**WI**	**Avg**	**WI**	**Avg**	**WI**
P1.	**Immunization**						
fi	Full Immunization: Basic coverage before 3 years old (BCG, DPT, Measles)	.09	.18	.09	.15	.09	.17
fi_BCG	Full Immunization: BCG	.05	.08	.04	.06	.04	.06
fi_DPT	Full Immunization: DPT	.06	.11	.06	.09	.07	.12
fi_Measles	Full Immunization: measles	.08	.15	.07	.11	.12	.18
ni	No-Immunization	.12	.18	.25	.36	.48	.62
P2.	**Antenatal Care**						
ancvisit	At least 1 antenatal care visit received from a medically trained person	.04	.06	.03	.04	.03	.04
ancvisit3	3 or more antenatal care visits	.05	.08	.06	.09	.05	.08
anc_tt	Tetanus toxoid	.04	.05	.03	.04	.02	.03
P3.	**Fertility and Nutrition**						
mcuse	Use of modern contraceptives	.05	.08	.04	.07	.04	.07
complfeed	Timely complementary feeding	.15	.21	.15	.19	.13	.18

Table 2c. Data Quality: Modified Coefficients of Variation – Treatment

	NFHS wave Survey years	I 1993/4		II 1998/9		III 2005/6	
Indic	**Indicator description**	**Avg**	**WI**	**Avg**	**WI**	**Avg**	**WI**
T1.	**Treatment of Children Diseases**						
diat	Treatment of diarrhea	.08	.15	.08	.13	.10	.18
ors	Use of ORS (Oral Rehydration salts, used in the treatment of dehydration often caused by diarrheal or intestinal disease)	.16	.27	.12	.22	.24	.42
fevt	Treatment of fever	.05	.09	.08	.16	.06	.10
arit	Treatment of ARI (Acute Respiratory Infection)	.08	.14	.06	.11	.08	.14
T2.	**Child Delivery**						
attdeliv	Last child delivery was attended by a medically trained person	.07	.11	.06	.10	.06	.09
delhom	Delivery at home	.05	.07	.07	.10	.07	.11

Table 2d. Data Quality: Modified Coefficients of Variation – Public Sector Share

	NFHS wave Survey years	I 1993/4		II 1998/9		III 2005/6	
Indic	**Indicator description**	**Avg**	**WI**	**Avg**	**WI**	**Avg**	**WI**
Z1.	**Treatment**						
diapub	Treatment of diarrhea in a public facility	.26	.45	.28	.50	.40	.66
fevpub	Treatment of fever in a public facility	.20	.38	.25	.46	.32	.57
aripub	Treatment of ARI (Acute Respiratory infection) in a public facility	.29	.51	.30	.51	.42	.65
delpub	Delivery in a public health care facility	.13	.22	.14	.24	.14	.23
Z2.	**Prevention**						
mcpub	Use of modern contraceptives: public source	.03	.05	.04	.05	.04	.06

Based on Tables 1a-d and 2a-d, several indicators can be excluded from consideration for inclusion into the index. In the outcome category, adolescent fertility is based on low sample sizes and is missing for too many states. In the prevention category, complementary feeding is not available for some or all parts of five states in 1993, and ten states in 1998 and 2005; values of its MCV are also on the high side. Within the nutrition group, the measure of obesity is of lower quality based on MCV for all three waves. Since there are already two other measures of nutrition, obesity is dropped.

2.3 Formatting the data set

The dataset used so far is organized with indicators appearing as specific observations stacked vertically. The observation ID records the state code, part (all/rural/urban) and the survey round. There are, however, as many observations with the same ID as there are indicators. This is a convenient setup to calculate concentration and achievement indices as well as coefficients of variations for all indicators at once. In order to construct an index of locations based on multiple indicators, however, one needs to have all indicators as variables and a single observation per ID (location). This new organization is convenient to calculate correlations between indicator values, sort the data by indicator values, and carry out principal components analysis with indicator values as components. A new data set is therefore constructed (see the Stata do file IndexDataPrep.do). In the new data set, indicators are renamed so as to include their category in the name (for exemple fi becomes P1_fi to indicate that full immunization is categorized in the first category under Prevention. The name of the indicator is then used to precede the statistic, forming one variable per indicator per statistic (for example P1_fi_av is a variable with full immunization rates averaged over the location). The data set thus constructed includes a unique identifier per observation based on the state, state part, and survey round. Thirty indicators are left in the data set, with eight variables per indicator: the average and seven extended achievement indices (v=2 to 8) for a total of 240 indicator variables plus identifiers. Identifiers left in the data set are:

- ID: for example for Punjab first survey round the IDs are PJ21, PJRur21, and PJUrb21
- stcode: two to three letter code used to identify the state.

- part: whether the observation refers to rural areas of the state (Rural), urban areas of the state (Urban) or the full state (Both).

- round: 21 for 1993/4; 41 for 1998/9; and 50 for 2005/6

- Pop2001: March 2001 Full state populations from the Indian Census. The state populations are used to recreate areas equivalent to pre-2000 states for states that were split up.

Table 3 gives a sample of the new data set for two state (Punjab and Kerala), two indicators (Infant Mortality rate and Full Immunization), two NFHS waves (II and III) and two statistics (Average and Wagstaff Index v=2). Summary statistics on all indicators are given in Table 4.

Table 3. Structure of the ISHAD_Index data set

ID	state	stcode	Part	round	O1_imr_AV	O1_imr_W2	P1_fi_AV	P1_fi_W2
KE41	Kerala	KE	Both	41	20.86	22.77	73.40	70.79
KE50	Kerala	KE	Both	50	17.70	21.01	75.16	69.45
KERur41	Kerala	KE	Rural	41	22.47	25.28	72.89	70.37
KERur50	Kerala	KE	Rural	50	20.49	23.22	69.39	62.98
KEUrb41	Kerala	KE	Urban	41	14.76	.	75.55	.
KEUrb50	Kerala	KE	Urban	50	11.64	.	87.32	.
PJ41	Punjab	PJ	Both	41	56.80	67.29	71.28	60.89
PJ50	Punjab	PJ	Both	50	44.92	49.73	59.75	48.02
PJRur41	Punjab	PJ	Rural	41	62.74	71.04	66.13	56.09
PJRur50	Punjab	PJ	Rural	50	46.19	50.71	57.58	46.83
PJUrb41	Punjab	PJ	Urban	41	39.60	.	84.31	.
PJUrb50	Punjab	PJ	Urban	50	42.58	.	64.38	.

Table 4. Summary statistics on indicator averages, all years and all observations

Indicator	Description	N	Mean	Std. Dev.	Min	Max
o1_imr	Infant mortality	175	60.56	22.04	11.64	126.50
o1_u5mr	Under-Five mortality	175	79.58	32.21	13.77	175.48
o2_tfr	Total Fertility	180	2.41	0.85	0.90	5.16
o3_stunt2	Severe Stunting	165	23.04	8.69	6.46	45.65
o3_stunt12	Severe & moderate stunting	165	45.00	10.15	21.54	65.97
o3_undw2	Severe underweight	180	15.64	6.99	2.72	37.01
o3_undw12	Severe & moderate underweight	180	38.79	10.60	16.20	61.75
o4_ari	Prevalence of ARI	179	11.34	7.08	0.78	30.60
o4_dia	Prevalence of diarrhea	178	12.58	6.94	2.36	32.57
o4_fev	Prevalence of fever	180	22.04	8.82	4.03	45.82
p1_fi	Full immunization	173	51.76	20.27	9.08	96.17
p1_fibcg	BCG immunization	170	79.69	16.11	31.27	99.74
p1_fidpt	DPT immunization	173	66.52	20.02	22.81	99.79
p1_fimea	Measles immunization	173	62.45	20.37	12.66	96.79
p1_ni	No-immunization	157	13.31	12.13	0.52	55.76

Indicator	Description	N	Mean	Std. Dev.	Min	Max
p2_anctt	Antenatal Care: use of tetanus toxoid	180	81.99	14.40	31.56	99.94
p2_ancv3	Antenatal Care: 3 visits or more	180	62.04	23.63	10.59	99.35
p2_ancv	Antenatal Care: at least one visit	177	76.65	19.87	19.73	99.42
p3_mcuse	Modern contraceptive use	180	46.80	12.37	15.77	71.15
t1_ari	Treatment of ARI	176	73.69	13.28	35.64	98.16
t1_dia	Treatment of Diarrhea	177	66.79	12.87	26.31	93.38
t1_fev	Treatment of fever	180	67.07	16.55	29.06	96.88
t1_ors	Use of ORS in treatment of diarrhea	178	44.10	16.45	12.69	88.89
t2_attdel	Attended Delivery	179	55.01	23.65	11.63	99.41
t2_delhom	Delivery at home	178	53.05	25.72	0.59	92.71
z1_ari	Treatment of ARI: public share	174	21.55	11.31	3.02	53.67
z1_dia	Treatment of diarrhea: public share	170	20.14	10.65	1.63	77.78
z1_fev	Treatment of fever: public share	179	18.01	10.50	2.96	48.30
z2_del	Attended delivery: Public facility	180	25.09	15.21	2.51	74.25
z2_mc	Contraceptive use: Public source	180	70.48	14.50	28.09	96.78

3. FIXED WEIGHT HEALTH ACHIEVEMENT INDEX (ISHAI_FW)

The construction of a fixed weight index involves selecting a small number of indicators and choosing weights. The following is indicative of what can be done and can be easily modified based on new information and expert opinions. Such an index could be constructed to fit specific conditions in one country and compare areas within the country as is done here for India. It can also be made general enough to fit all DHS country for cross country comparisons. Resulting rankings of Indian States for the period 1992 to 2006 are presented in section 3.2.

3.1 Construction of the index

3.1.1 Selection of indicators

When selecting the indicators for the fixed weight index, once data availability and quality is taken into account, one needs to consider two additional criteria:

#1 whether the indicator can capture a given dimension of the health sector (signaling performance in other related areas)

#2 the importance of the indicator itself as a signal of performance in health

Part of this process is obviously subject to judgment calls on the part of the investigator, in particular criteria #2. It is therefore important to outline the selection process and be explicit about the reasoning behind the inclusion of one indicator versus another.

Criterion # 1, however, can be informed by looking at correlations between indicators within and across broad categories. While the health index cannot be based on totally uncorrelated elements, there is no need to use multiple indicators when the correlation between

them is large. A full correlation matrix is used to check correlations across categories.[7] All health indicators are significantly correlated except for indicators of incidence of diseases in children (Diarrhea, fever, and ARI) that are correlated with each other but show low correlation with other groups. Indicators of public share are not or only slightly correlated with other categories except for the share of attended deliveries performed in a public facility. The inclusion of the first category will therefore depend mostly on criterion #2. The issue of including or excluding the public share category is discussed at the end of this section. The following discussion/takes each category separately to identify indicators that would best represent their category based on the group specific correlation matrix (Tables 5a-d). Recommendations for inclusion in the index are given following each table.

Indicators in category 1 and 2 of outcomes all present a correlation greater or equal to 0.74 while correlations between category 1-2 and category 3 is low and, in some cases insignificantly different from 0 (Table 5a). If prevalence of diseases in children is a category judged important to include, it will not be captured by other outcome indicators. Infant mortality rates and under 5 mortality rates are highly correlated, as expected, under 5 mortality rate is slightly more correlated with stunting, if stunting is not included, under 5 mortality rate should be chosen instead of IMR. In the third category, prevalence of diarrhea and prevalence of ARI show the lowest correlation at 0.41. Prevalence of ARI, is more highly correlated with prevalence of fever (0.72) than diarrhea but prevalence of diarrhea is more highly correlated with outcome indicators in the other groups than the other 2 in its category (although the highest correlation with total fertility is still less than 30 percent). Based on this table, if one indicator per group of outcomes needs to be chosen on the basis of representativeness, it would be under five mortality, total fertility, and severe underweight. To reduce the number of outcome indicators to three: u5mr, severe underweight, and prevalence of fever.

Table 5a. Correlation between Indicator Averages – Outcomes

	O1 imr	O1 u5mr	O2 Tfr	O3 undw12	O3 undw2	O3 stunt12	O3 stunt2	O4 dia	O4 fev
O1_imr	1								
O1_u5mr	0.98	1							
O2_tfr	0.72	0.78	1						
O3_undw12	0.76	0.78	0.67	1					
O3_undw2	0.76	0.79	0.71	0.94	1				
O3_stunt12	0.77	0.80	0.79	0.79	0.79	1			
O3_stunt2	0.76	0.80	0.81	0.74	0.82	0.94	1		
O4_dia	0.17	0.16	0.26	0.16	0.19	0.15	0.18	1	
O4_fev	0.02	0.02	0.14	-0.04	0.00	-0.04	0.01	0.56	1
O4_ari	0.13	0.14	0.06	0.04	0.05	0.04	0.08	0.41	0.72

Table 5b reveals high correlation between all preventive health indicators. A correlation coefficient above 0.81 between BCG full immunization and all other indicators indicates that if one indicator had to be chosen as a representative of the category, BCG immunization would be

[7] The full correlation matrix is not reproduced in this document but is available as a Worksheet attachment (Corr_all.xls).

the best one for this data set. All other indicators of immunization, however, would be fine. Based on availability in table 2b, full immunization will allow a larger representation of states. If one can include one indicator of preventive health per subgroup, full immunization (fi) along with Antenatal care 3 visits (ancv3) and modern contraceptive use would seem to capture the greatest variation. No-immunization is the least correlated with any of the others except BCG; The ancv3 indicator has high correlation with others but lower correlation with ni.

Table 5b - Correlation between Indicator Averages – Prevention

	P1 fi	P1 fiBCG	P1 fiDPT	P1 fiMea	P1 ni	P2 ancv	P2 ancv3	P2 anctt
P1_fi	1							
P1_fiBCG	0.89	1						
P1_fiDPT	0.96	0.91	1					
P1_fiMea	0.95	0.95	0.93	1				
P1_ni	-0.67	-0.84	-0.66	-0.76	1			
P2_ancv	0.72	0.83	0.74	0.77	-0.74	1		
P2_ancv3	0.77	0.81	0.83	0.77	-0.61	0.86	1	
P2_anctt	0.78	0.88	0.79	0.82	-0.87	0.88	0.81	1
P3_mcuse	0.75	0.84	0.75	0.84	-0.69	0.74	0.72	0.75

Treatment indicators are separated into 2 categories: treatment of children diseases (T1) and child delivery services (T2). Table 5c gives correlation coefficients within and between the two categories of treatment. Attended delivery and delivery at home are, by construction highly negatively correlated, the use of one versus the other should not make a difference in the index. Attended delivery is slightly more correlated with the other treatment variables. If using one indicator from each subgroup, the treatment of diarrhea, being positively correlated with all the others in the group with at the lowest coefficient at 0.42, would be a good candidate for T1.[8]

Table 5c. Correlation between Indicator Averages – Treatment

	T1 dia	T1 ors	T1 Fev	T1 ari	T2 attdel
T1_dia	1				
T1_ors	0.47	1			
T1_fev	0.42	-0.20	1		
T1_ari	0.69	0.25	0.56	1	
T2_attdel	0.40	0.26	0.35	0.52	1
T2_delhom	-0.33	-0.27	-0.30	-0.45	-0.98

[8] Treatment of fever would have been a good choice on the basis of data availability but the negative correlation with the use of ORS could be problematic.

Correlations between indicators measuring the importance of the public sector in the provision of health services category are presented in Table 5d.[9] We stated before that indicators in this category were kept into the analysis because, particularly when it comes to treatment, the use of private facilities could be commended by the lack of public provision for a specific service. The full correlation matrix, however, indicates that correlation between other categories and public share in treatment is low and often insignificantly different from zero. The only correlation above .30 aside from public share in delivery services is the use of ORS in treatment and the public share of ARI treatment. When it comes to contraceptive provision and attended delivery, public shares are more correlated with other categories but the proportion of attended deliveries in a public facility is negatively correlated with outcome and prevention indicators. One conclusion from this exercise is that the relationship between public shares across different health services is complex and inclusion a priori in an index would be controversial. Since the problem associated with a low public share in terms of public health is mostly associated with issues of reaching the poor. An index based on Wagstaff Indices with large enough value of inequality aversion is likely to incorporate this dimension. The public share category is therefore left out of the fixed weight index.

Table 5d. Correlation between Indicator Averages – Public Share

	Z1_dia	Z1_fev	Z1_ari	Z2_del
Z1_dia	1			
Z1_fev	0.73	1		
Z1_ari	0.76	0.82	1	
Z2_del	0.34	0.28	0.35	1
Z2_mc	0.23	0.31	0.24	-0.32

Given the considerations above on data availability, quality, importance of a given dimension of health, and correlations between indicators, I suggest, subject to discussion, that the following indicators be included in the fixed weight index:

Outcomes: under five mortality rate (O1_u5mr), fertility (O2_tfr), severe underweight (O3_undw2), and prevalence of fever (O4_fev)

Prevention: Full immunization (P1_fi); Antenatal Care, at least 3 visits (P2_anc3); and use of modern contraceptives (P3_mcuse)

Treatment: Treatment of Diarrhea (T1_dia); and attended delivery (T2_del).

[Note: The index is constructed with these variables as an example of what can be done and to give something useful to move forward; the composition of the index can easily be changed after discussions. The same applies for weights discussed below].

[9] The correlation between the share of modern contraceptive from a public source and the share of attended delivery performed in public facilities was checked for the three waves of the NFHS separately, the same negative correlation results within each wave (0.37 in 1992/3, 0.33 in 1998/9, and 0.14 in 2005/6).

3.1.2 Indicator Values

A separate index score is created for each indicator. It is important that the values of the indicators themselves do not influence the weight given to a certain dimension of the full index. This would happen if indicators of "bad" were left as such and if expected ranges of different indicators vary. It also happens if the dimension in which an indicator is measured vary by indicator, which is the case here.

Let us take for example four indicators, one "good" and three "bads", all with very dissimilar ranges: antenatal care as "good" and under five mortality rate, total fertility, and no-immunization as "bads". Mortality is measured per thousand live births in the 10 years preceding the survey; fertility is measured as number of children a women would have in her lifetime given fertility rates at each age, no-immunization and antenatal care are expressed as a percentage. Although full-immunization is used in the index, no-immunization is used here to illustrate the point. Suppose that there are only 3 states, X, Y, and Z. X is the best performing state, Y the worst, and Z is a state in the middle of the range. We denote μ_i the mean of a given indicator for state I (i=X,Y,Z).

μ_X=99 and μ_Y=10 and μ_Z=54.5 for antenatal care

μ_X=0.5 and μ_Y=55 and μ_Z=27.75 for no-immunization

μ_X=13.8 and μ_Y=175 and μ_Z=94.4 for under five mortality

μ_X=0.9 and μ_Y=5 and μ_Z=2.95 for total fertility

Using I_i to denote the index score of a given indicator for state I, the index could be calculated as $I_i= \mu_i/\mu_X$ for positive indicators and $I_i= \mu_X/\mu_i$ for negative indicators. With this method, the order is preserved but the values assigned greatly influence the weight given to each indicator. Using the four indicators in our example, the score thus obtained are:

I_X =100 ; I_Y =10.1; and I_Z = 55.6 for antenatal care

I_X =100 ; I_Y =0.91; and I_Z = 1.8 for no-immunization

I_X =100 ; I_Y =7.9; and I_Z = 14.5 for mortality

I_X =100 ; I_Y =18; and I_Z =30.5 for fertility

A state in the middle of the range for all indicators will have an overall index value largely dominated by antenatal care and to a lesser extent fertility, once the different dimensions of health are aggregated.

In order to correct the problem, one can measure distances within a given range for each indicator. The score of one state is then based on the distance between that state and the best performing state relative to the distance between the best and worst performance. For country i, the index becomes:

I_i =100 * abs{(μ_i-μ_Y)/ (μ_X-μ_Y) },

where subscript X and Y still denote the best and worst performing states, respectively.

Using this methodology the range for all indicators is from I=0 for the worst performing state, I=100 for the best, and I=50 for the middle of the range. This method has the advantage of treating each indicator the same way and be dimension free. One disadvantage to keep in mind is

that, when the range is allowed to vary to fit the data considered and the indices are compared across time/samples, they will not show convergence or divergence as gaps are narrowing or increasing over time. When using the index over time or for multiple samples, it is possible to fix the worst value of a given indicator and calculate scores based on that value. Here, there are three years of data and separate rural/urban numbers. By calculating all scores relative to the broadest range all years and geographical areas confounded, one can identify convergence or divergence over the three survey years and compare rural/urban areas. The range of the index will therefore not necessarily be 0-100 when looking at a single survey round or a specific grouping.

3.1.3 Weights

Since weights must be arbitrary assigned, the following will be based on a simple weighing system that resembles the weights of the UN Human Development Index. Each dimension (Outcomes, Prevention, and Treatment) will constitute 1/3 of the value of the index. Within each category, equal share is given to the indicators chosen. The Index proposed here is therefore composed of the following

ISHAI_FW = 1/3 Outcomes+ 1/3 Preventive + 1/3 Treatment

Outcomes = 1/4 (mortality score) + 1/4 (fertility score) + 1/4 (nutrition score) + 1/4 (child morbidity)

Preventive = 1/3 (Immunization score) + 1/3 (Antenatal Care score) + 1/3 (Modern contraceptive use score)

Treatment = 1/2 (diarrhea treatment score) + 1/2 (attended delivery score)

3.2 Fixed weight index: results and analysis

Before constructing the index, states that were split in 2000 are reconstituted to be comparable to the "old" states. While the split would not be much of an issue for Uttar Pradesh that kept 95 percent of its population, it would likely make a difference when comparing old Bihar to new Bihar and old Madhya Pradesh to new Madhya Pradesh as both lost about 25 percent of their populations. The two new states emerging of each "old" state are combined by using a weighted average of the indicators.[10] When looking at 2005/6 the new states will be used but when comparing over time, the 2005 "old" Bihar will include Jharkhand, the 2005 "old" Madhya Pradesh will include Chhatisgarh, and the 2005 "old" Uttar Pradesh will include Uttaranchal (later Uttarkhand).

In the following, I use a fixed reference for the range of indicators based on the best performance and the worse performance over the whole range of observations (states and parts of states) and years. The index thus calculated can show absolute trends rather than relative changes. All figures are based on index numbers given in Appendix tables. The numbers

[10] The weights are based on full state relative populations in April 2001 (Census). Rural and urban areas are reconstituted using weights based on relative sizes in the NFHS sample (the NFHS sample was selected to match rural/urban proportions of the population). It is worth noticing that the weights for rural urban areas closely match those for the full states.

obtained for each component of the index (outcomes, prevention, treatment) are also given in the Appendix.

3.2.1 Non adjusted index (based on levels only)

All 20 states in the sample are represented in the full state index. While both rural and urban parts of the states are represented in the full state sample, some states are not represented in rural/urban samples because of low sample sizes that created missing observations for some components of the index. This is the case of rural New Delhi and urban Tripura for all waves, urban areas of Assam, Goa, and Himachal Pradesh in 1998/9, and Himachal Pradesh and Kerala in 2005/6.

Full states (Figures 1 and 2). Figure 1 represents values of the Fixed Weight Indian States Health Achievement Index (ISHAI_FW) by state in 1992/3, 1998/9, and 2005/6, ranked by 1992/3 performance.[11] The scores are based on indicator means. A list of state codes in given in the appendix. The data is ordered starting from the state with the highest composite score in 1992/3. Figure 2 show changes in rankings of states for all three waves of the NFHS based on ISHAI_FW. It is important to look at both sets of figures as the first set gives a better idea of absolute changes whereas the second one gives a picture of relative changes without considering distance between states.

All states show a composite improvement between 1992 and 2006. A few states had slightly regressed or stagnated between 1992/3 and 1999 (Goa, Madhya Pradesh, Rajasthan, Uttar Pradesh, and Bihar) but they all more than caught up between 1999 and 2006. At the top of the distribution, Tamil Nadu performed best during the whole period; looking at the breakdown of the index, it showed significant progress along all three dimensions (outcomes, prevention, and treatment). Goa lost its number one ranking after 1992/3 in favor of Tamil Nadu and Kerala but stayed in the top three across the period. Punjab improved at a slower pace than other states dropping from 3rd in 1992/3 to 6th place in 2005/6. Maharashtra, despite a slight loss in the beginning of the period gained four ranks to finish 4thin 2005/6. At the bottom, Assam performed relatively better than old Bihar and old Uttar Pradesh. Orissa performed better than Madhya Pradesh and Rajasthan going from 17th to 14th. In the middle of the pack, Haryana passed Jammu and Gujarat. Overall, however, the rankings stayed rather stable during the period.

[11] The rural parts of New Delhi are included in the full state data.

Figure 1. Fixed weight ISHAI (ISHAI_FW) – 20 Indian States

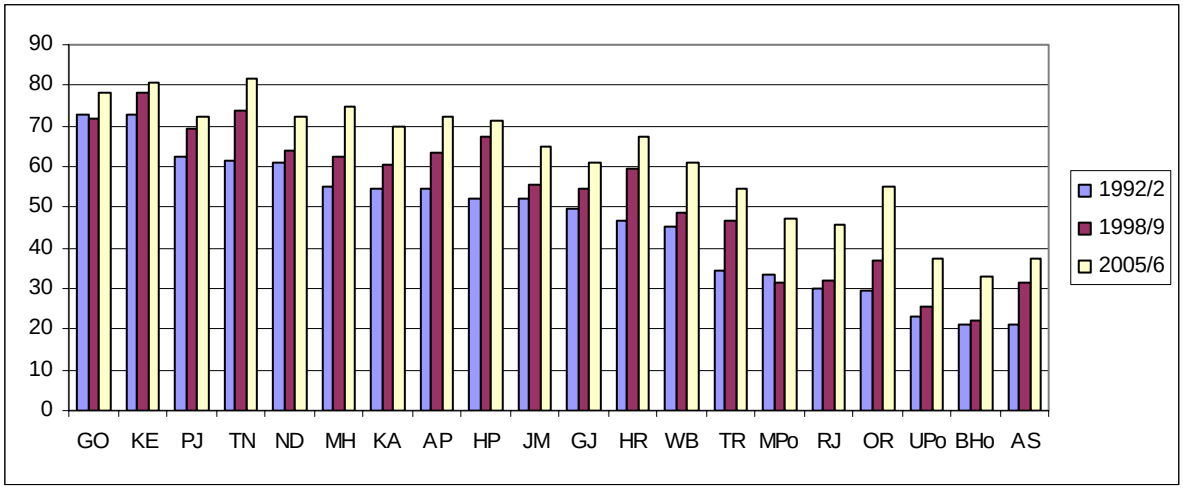
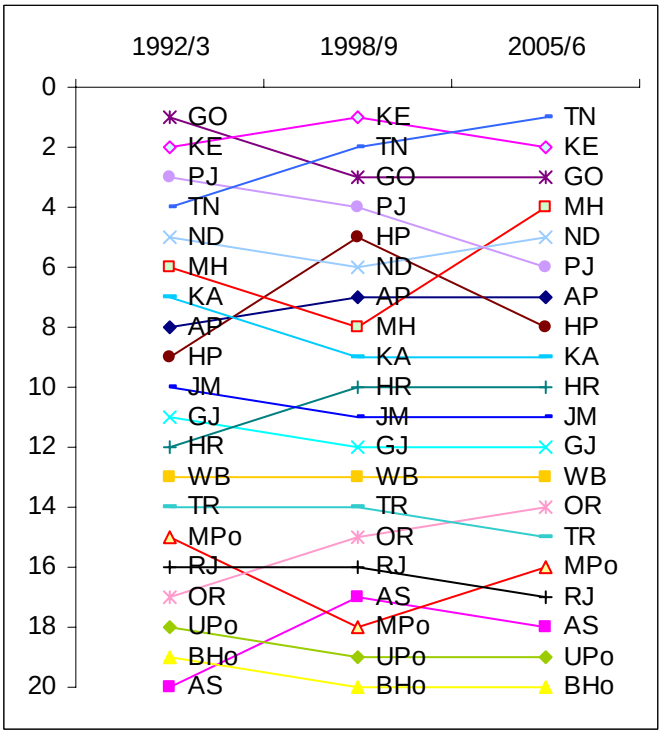


Figure 2. ISHAI_FW Ranking 1992/3 to 2005/6 – 20 Indian States



Rural Areas versus Urban Areas (Figures 3 to 6). In order to see differences of performance between rural and urban areas of each state, indices for rural and urban areas are calculated using rural/urban specific indicators. Given the smaller sample sizes, some data is missing for some states/years. Tripura did not have enough data to be included in the urban analysis and New Delhi was dropped from the rural analysis. For states that were only missing one or at most two indicator scores for a given year, the missing value was replaced by its full

state value to give an approximation of the overall score. The states with partial data were, however, dropped from the rankings.

The break down reveals some differences between rural and urban areas in terms of overall performance and changes over time. As expected, the value of the index is altogether higher in urban areas. The largest gains during the period were registered in rural areas, indicating some convergence between rural and urban areas. The distribution of scores stayed wider in rural India than urban India with a largest difference of about 50 in rural India and 30 in urban India.

Figure 3. Fixed Weight ISHAI – Rural India (19 states)

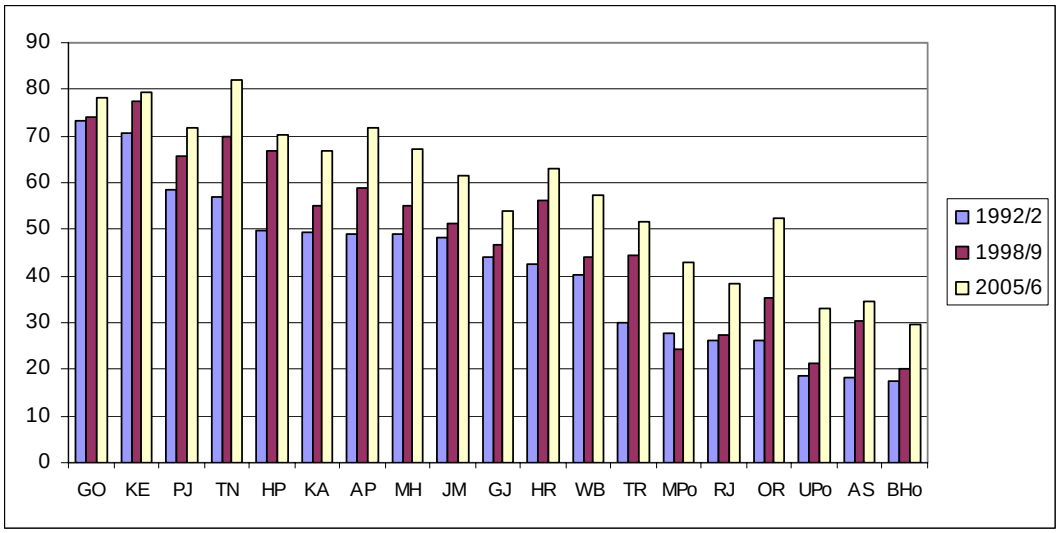
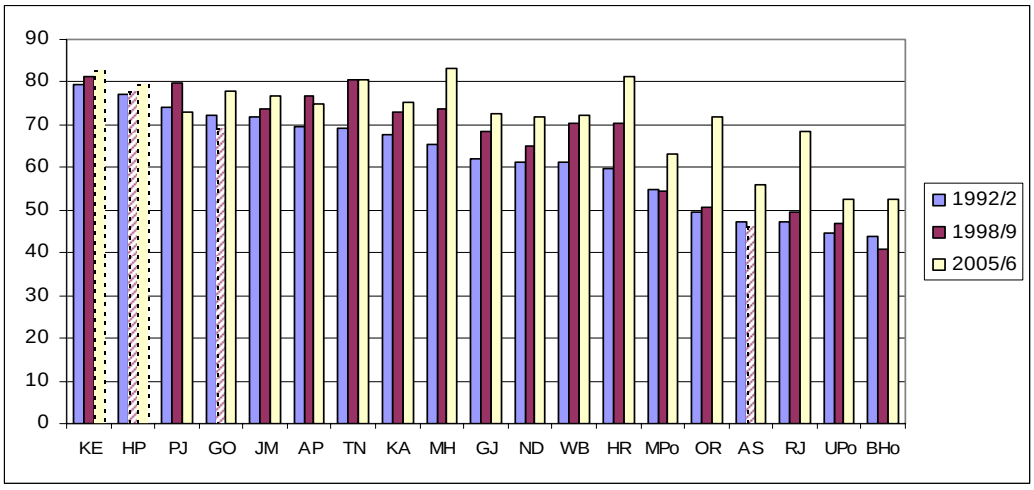


Figure 4. Fixed Weight ISHAI – Urban India (19 states)[(*)]



[(*)] The dashed lines are based on two out of three index components for urban areas. The missing component is replaced by its value for the full state.

The rankings are somewhat different with some states (Goa and Tamil Nadu) better ranked among rural areas while other states (Assam and Jammu/Kashmir) are better ranked among urban areas. While the rankings and changes in rankings in rural areas follow closely those of the full states, the breakdown by urban areas shows greater differences in performance during the period. The worse performance in urban areas is that of Punjab that went from first to 7th in the urban group while it only lost one rank in rural areas. The good performance of Maharashtra appears driven by its urban areas while that of Tamil Nadu is driven by its rural areas. Madhya Pradesh (in its old configuration) owns its recovery in 2005/6 to performance in rural areas only. The good performance of Andhra Pradesh overall is also due to its rural areas exclusively; when looking at urban areas only, it was overtaken by four states between 1999 and 2006.

Figure 5. ISHAI_FW Rankings 1992/3 to 2005/6 – Rural India (19 States)

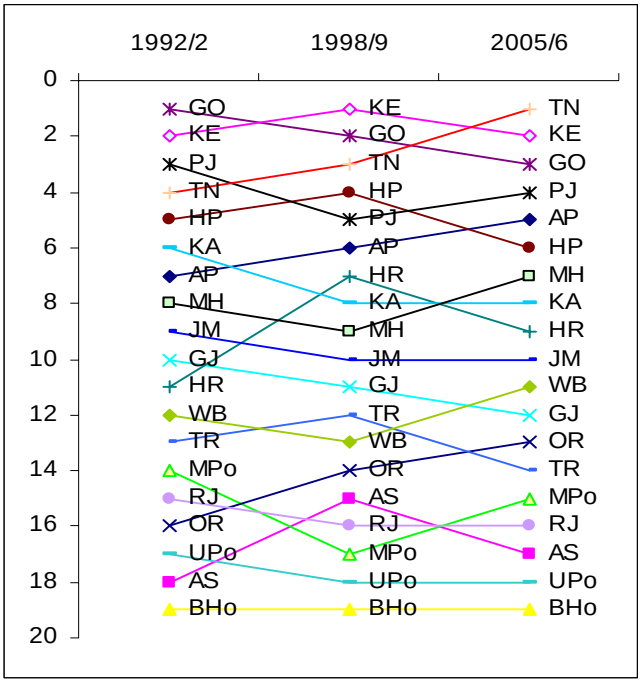
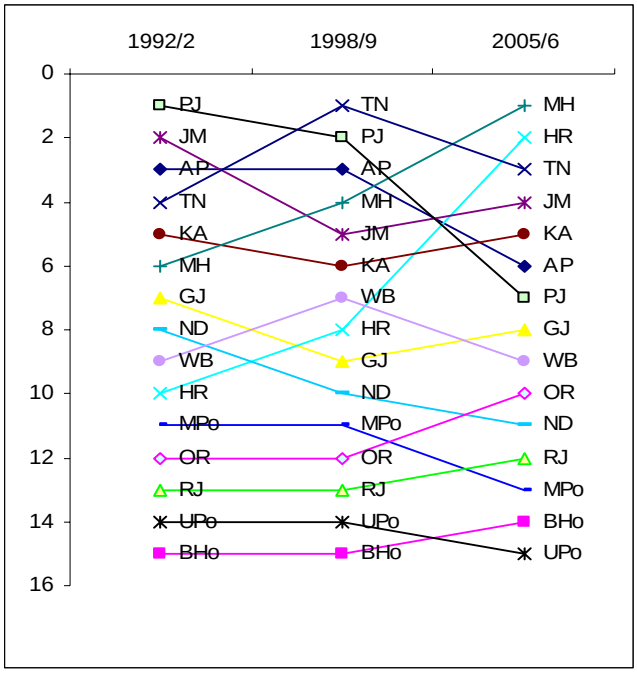


Figure 6. ISHAI_FW Rankings 1992/3 to 2005/6 – Urban India (15 states) (*)



(*) Only states with non-missing index values for all years are included in the ranking. For states with partially available data, see the corresponding bar graph..

3.2.2 Equality adjusted fixed weight index (ISHAIEQ_FW).

Instead of calculating scores using averages, the scores are based on achievement indices for various degrees of risk aversion. Unfortunately, the number of states represented is limited by the fact that data by quintile often had to be dropped as it was based on sample sizes too small for meaningful inference. In particular, the analysis could not be done for urban areas as only one to four states had complete data by quintile depending on the survey year. New Delhi had missing data by quintile for all preventive and treatment indicators in 2005/6 (why?), it is kept in the analysis for 1992/3 and 1998/9. Tripura did not have enough information at all levels and had to be dropped from the sample altogether.

We look at two levels of inequality aversion, low and high. The base level, v=2, uses the same weighing by quintiles as a Gini coefficient or regular concentration index/achievement index. The high degree of risk aversion (v=8) places virtually all weight on the lowest quintile. The index can be easily calculated for any degree of inequality aversion depending on the goal of the investigator.[12] We note that the correlation between non-adjusted averages of indicators and their achievement index value is very high (from an average of 0.98 for v=2 to an average of 0.90 for v=8) so the equity adjusted index should not be much different than the non-adjusted index for this sample.

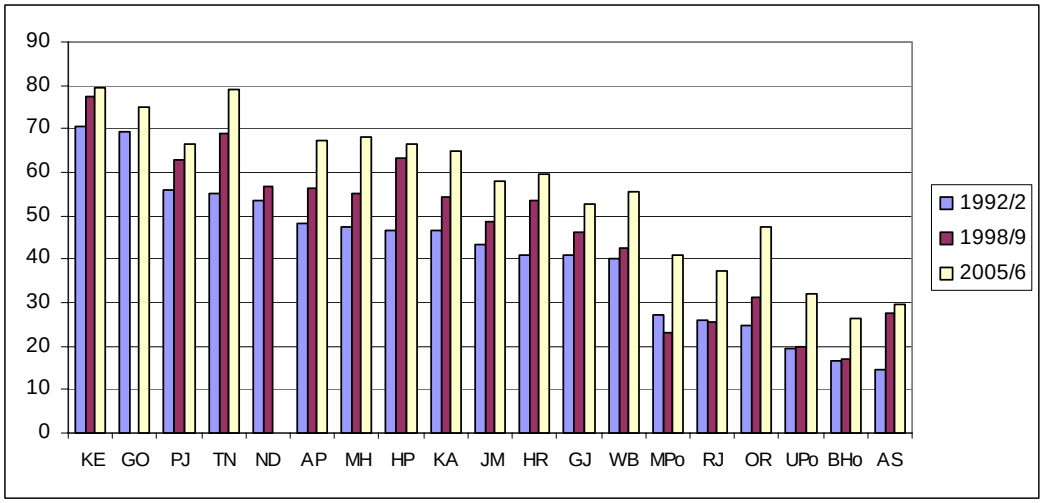
[12] A Stata program was written to calculate extended achievement indices based o grouped data for any level of inequality aversion (the commands are [genai] for the dataset with stacked indicators and [aigen] for the data set with all values of the indicators as variables). A Stata do file calculates the index for any level of inequality aversion (ISHAI_FW.do). These programs are available from the author.

Full states, equality adjusted index (Figures 7-10). Comparing changes in the inequality adjusted index with v=2 with those of the non-adjusted index does not reveal any significant differences despite a few slight changes in ranking.[13] Kerala keeps its number one place across the period (although data is missing for Goa in 1998/9). Bihar takes Assam's place at the bottom of the distribution in 2005/6 as it did in non-adjusted terms. What is more interesting is to look at how the index changes as more weight is put on lower quintiles. In the following, the base level of inequality aversion (v=2) in compared to the high level (v=8).

Although we would like to see larger progress at lower quintiles so as to eventually reduce inequalities, the general trend is that lower income quintiles improved similarly to the overall distribution (figures 7 and 8). A few states only show more progress at the bottom of the wealth distribution, in particular, Tamil Nadu in both periods, Jammu in the first period, and Kerala, Madhya Pradesh and West Bengal in the second period. Some states, however look like they are widening the gap as they improved at a slower pace in bottom quintiles (Bihar in both periods, and Orissa and Assam in the second period).

Looking at rankings (figures 9 and 10), the only difference that is noticeable when increasing the weight on lower quintiles is that Jammu did relatively better at the bottom of its wealth distribution: while it lost a rank overall and with the base inequality adjusted index, it gained two ranks at the highest level of inequality aversion, indicating better relative performance for its poor. Haryana did better in the bottom quintiles between 1992 and 1999 but worse between 1999 and 2006. Madhya Pradesh in the second period more than recovered its first period loss in the bottom quintiles.

Figure 7. Equality Adjusted Fixed Weight ISHAI (ISHAIEQ_FW) – 19 States – v=2(*)



[13] Note that the indices are calculated independently so values themselves cannot be compared across indices with different values of inequality aversion as they were for rural versus urban areas.

Figure 8. ISHAIEQ_FW – 19 states – v=8

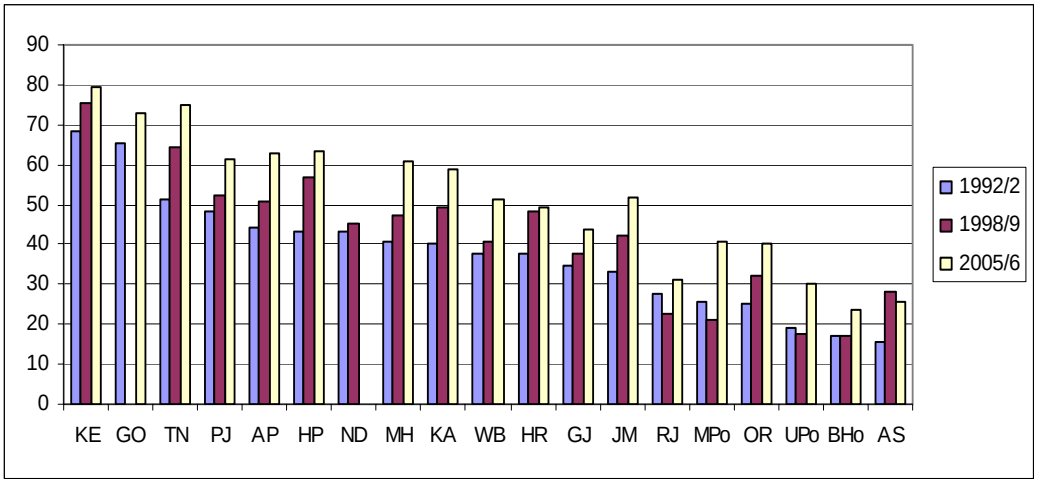


Figure 9. ISHAIEQ_FW: Ranking 1992/3 to 2005/6 – 17 States - v=2

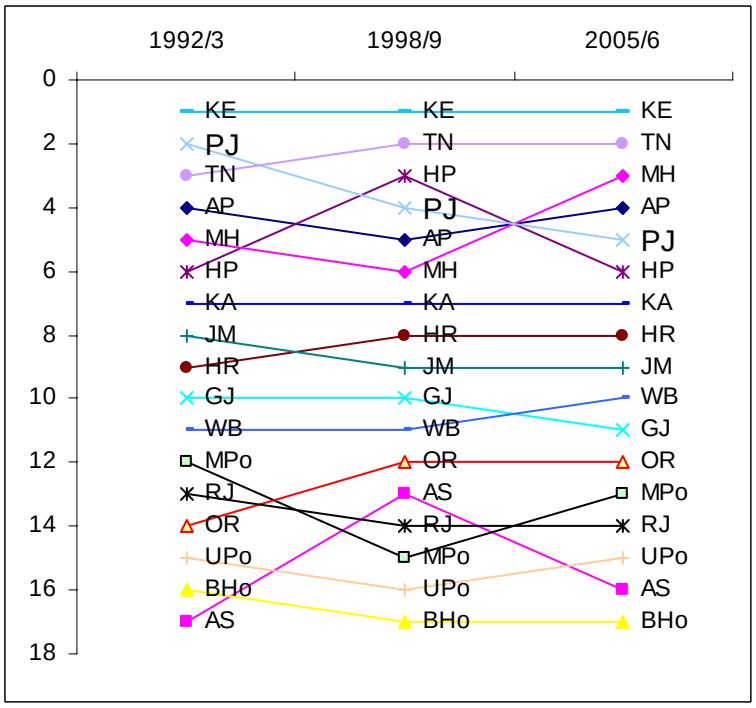
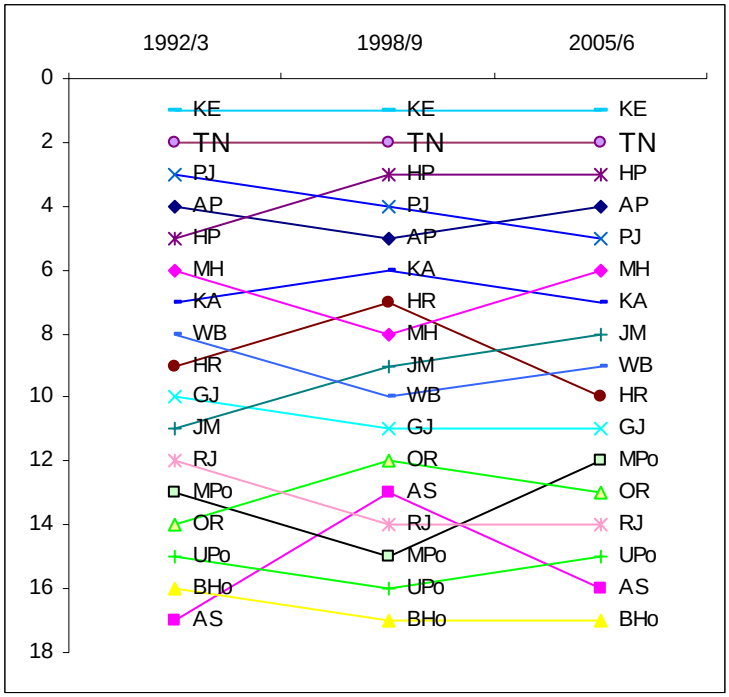


Figure 10. ISHAIEQ_FW: Ranking 1992/3 to 2005/6 – 17 States - v=8



Rural areas, equality adjusted index (Figures 11-14). Since the greatest part of most states is rural, not much is revealed by the equity adjusted index looking at rural areas only and comparing to the full state. We note, however, slower progress in lower wealth quintiles of rural areas of Gujarat, which was not apparent when looking at the whole state.

Figure 11. ISHAIEQ_FW – Rural Areas (18 states) – v=2 (*)

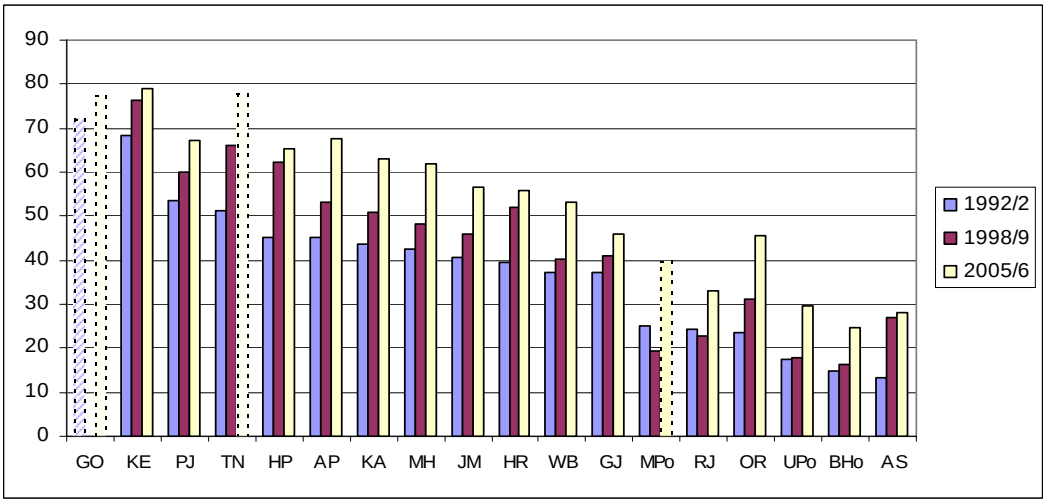
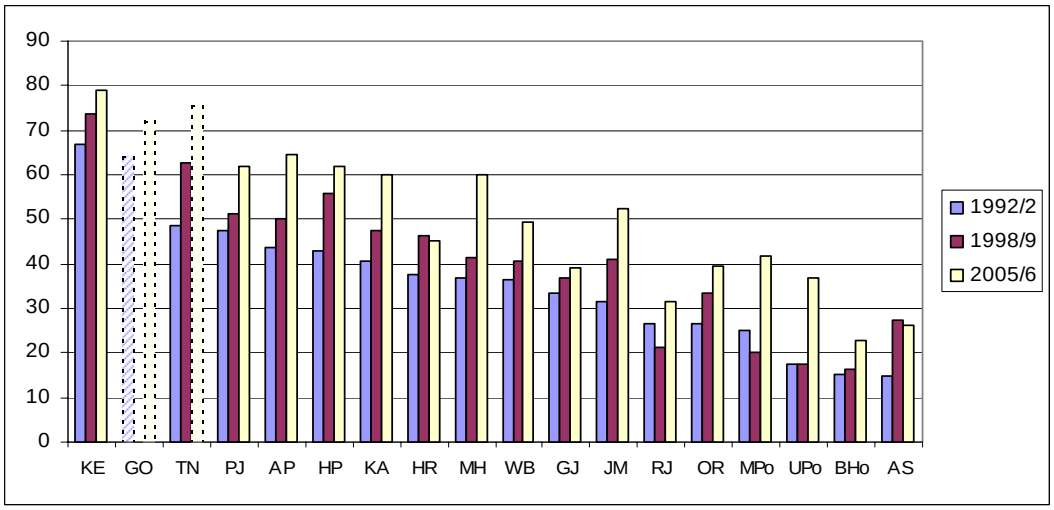
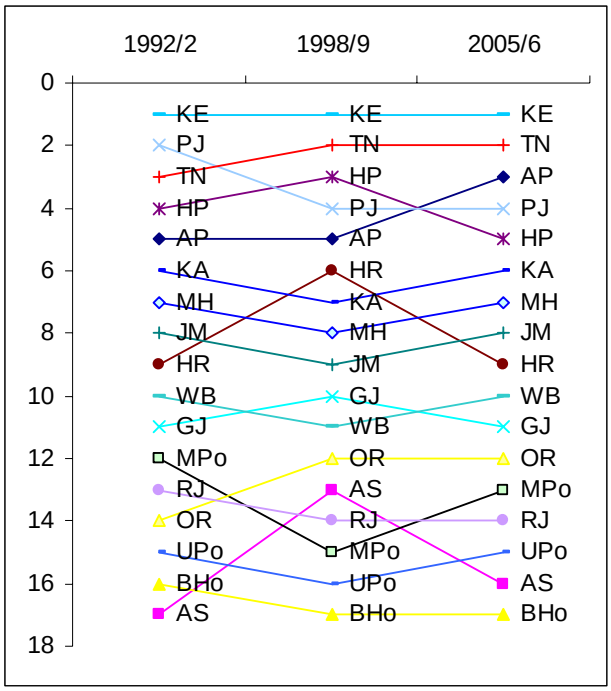


Figure 12. ISHAIEQ_FW – Rural Areas (18 states) – v=8 (*)



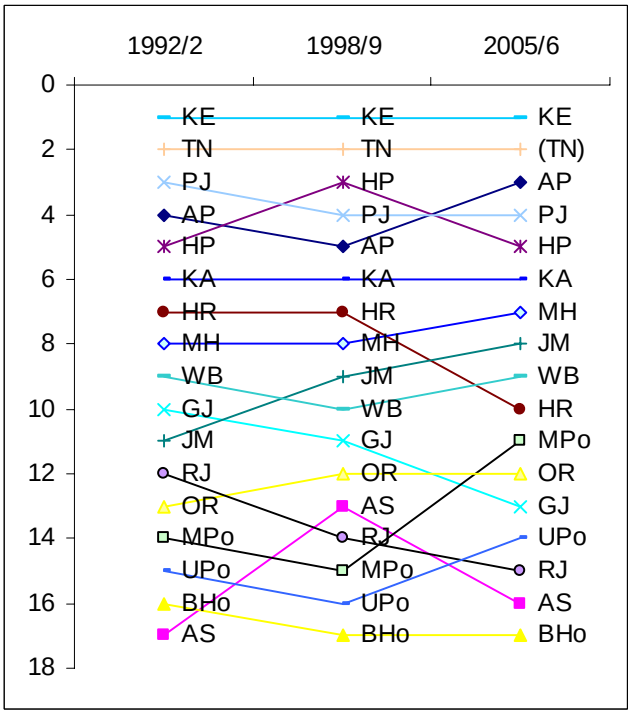
(*) The missing components for Tamil Nadu in 2005/6 (full immunization score), Goa in 1992 (under 5 mortality score) and Goa in 2005/6 (under 5 mortality and immunization scores) were replaced by full state numbers to approximate the equality-adjusted index. The numbers thus estimated are given in dashed lines.

Figure 13. ISHAIEQ_FW: Rankings 1992/3 to 2005/6 – Rural Areas - v=2(*)



(*) Tamil Nadu's rank in 2005/6 is based on an index estimated using full state data for full immunization

Figure 14. ISHAIEQ_FW: Rankings 1992/3 to 2005/6 – Rural Areas - v=8(*)



(*) The missing component for Tamil Nadu in 2005/6 (Preventive) was replaced by full state numbers to calculate the equality-adjusted index

Although more analysis needs to be done to better understand the distributional aspects of health sector improvements, this rapid examination of the data shows that trends are not greatly affected by the degree of inequality aversion one places into the index. Although rankings at the beginning of the period look slightly different with inequality adjustments, good performances in levels were apparently most often accompanied by similarly performances for the lowest quintiles while not so good performances carried over or became emphasized when greater weight was placed on lower wealth quintiles. This, of course, does not mean that the same trend is expected in all data sets, so it is important to calculate the equity adjusted index along with the non-adjusted index to understand distributional aspects of health achievements.

4. PRINCIPAL COMPONENTS INDEX (ISHAI_PC)

4.1 Construction of the index

While it was necessary to be parsimonious selecting the set of indicators to be included into the fixed weight index, the principal component method does not require such selection. The method itself is able to identify the contribution of each indicator in the overall variance and assign weights accordingly. However, one must be careful that a missing value for one indicator will create a missing value in the index. Consequently, it is important to remove indicators with missing values if other indicators can "replace" them. The following indicators are removed from the analysis on the basis of their low availability (see Tables 1a-d): adolescent fertility, stunting, obesity, BCG, no-immunization, timely complementary feeding, and treatment of ARI.[14] The indicators of public share are dropped on the basis of considerations explained in section 3.1.1.

Principal components (PC) analysis is run on the full set of data (all waves, all states/parts of state) in order to allow the largest comparison set.[15] Depending on whether one wants an index based on levels or an index based on equity adjusted numbers, the indicator values are the non-adjusted indicator averages or values of the Wagstaff Index at any degree of inequality aversion. Otherwise, the construction of the index is similar. Detailed results of the PC analysis given below are based on the indicators in levels. The analysis returns a set of values representing the contribution of each indicator to the principal components (the eigenvector) that are used to calculate scores for each observation (Table 6). The sign of the eigenvector indicates the direction of contribution of each indicator to the index. A negative outcome should get a negative sign and a positive outcome, a positive sign.

The weights given to each indicator in ISHAI_PC are given in the first data column of Table 7. Weights are the coefficients used to multiply values of each indicator to obtain the final index value. The constant term corresponds to the unexplained variation in the PC analysis. Since the weights are scale dependant, they are not directly comparable. The last three columns of Table 7 give the indicator's contribution to the index if the value of the indicator is at its worst, mean, and best values. Looking at these last three columns gives an idea of the scale-free weight given to each indicator.

[14] Any of these indicators can be added into the index easily if data availability improves. In particular, the stunting and obesity indicators can be added to the index if one is not looking at 1992/3 data.

[15] The analysis was also done separating full states, rural areas, and urban areas. The results were similar in terms of relative comparisons (state ranks and relative change over time).

Table 6. Principal Components (Eigenvectors)

Variable	Component 1	Component 2	Unexplained
o1_imr	-0.260	-0.005	0.234
o1_u5mr	-0.272	-0.010	0.164
o2_tfr	-0.242	0.003	0.339
o3_undw12	-0.239	-0.064	0.341
o3_undw2	-0.251	-0.041	0.282
o4_dia	-0.021	0.362	0.611
o4_fev	-0.013	0.536	0.158
o4_ari	-0.051	0.491	0.265
p1_fi	0.265	-0.023	0.201
p1_fidpt	0.266	0.027	0.196
p1_fimea	0.270	-0.026	0.173
p2_ancv	0.265	0.051	0.198
p2_ancv3	0.276	0.004	0.139
p2_anctt	0.263	0.030	0.213
p3_mcuse	0.227	-0.049	0.411
t1_dia	0.179	0.034	0.634
t1_ors	0.114	0.385	0.417
t1_fev	0.129	-0.420	0.294
t2_attdel	0.266	0.006	0.200
t2_delhom	-0.254	-0.031	0.267

Table 7. Contribution of Each Included Indicator to the Principal Components (PC) Score

		Indicator Range			Contribution to the PC score		
Indicator	**Coeff.**	**Worst**	**Mean**	**Best**	**Worst**	**Mean**	**Best**
o1_imr	-0.012	126.5	61.37	11.64	-1.57	-0.76	-0.14
o1_u5mr	-0.009	175.5	80.90	13.77	-1.54	-0.71	-0.12
o2_tfr	-0.291	5.16	2.42	0.90	-1.50	-0.70	-0.26
o3_undw12	-0.023	62.63	39.64	16.20	-1.41	-0.90	-0.37
o3_undw2	-0.036	37.01	16.11	2.72	-1.33	-0.58	-0.10
o4_dia	-0.003	32.57	12.39	2.36	-0.10	-0.04	-0.01
o4_fev	-0.002	45.82	21.49	4.03	-0.07	-0.03	-0.01
o4_ari	-0.008	30.60	11.06	0.78	-0.24	-0.09	-0.01
p1_fi	0.013	9.08	51.05	9.08	0.12	0.68	0.12
p1_fidpt	0.013	22.81	65.24	99.79	0.31	0.88	1.34
p1_fimea	0.014	12.66	61.89	96.79	0.17	0.85	1.32
p2_ancv	0.013	19.73	75.88	99.42	0.26	1.00	1.31
p2_ancv3	0.012	10.59	60.24	99.35	0.12	0.70	1.16
p2_anctt	0.019	31.56	81.94	99.94	0.59	1.53	1.87
p3_mcuse	0.018	15.77	46.50	71.15	0.29	0.85	1.30
t1_dia	0.015	26.31	66.25	93.38	0.39	0.97	1.37
t1_ors	0.007	11.82	42.61	88.89	0.08	0.30	0.63
t1_fev	0.008	29.06	67.38	96.88	0.24	0.55	0.80
t2_attdel	0.012	11.63	53.61	99.41	0.13	0.62	1.15
t2_delhom	-0.010	93.69	54.63	0.59	-0.95	-0.55	-0.01
Constant	-4.388	1	1	1	-4.39	-0.76	-4.39
Total score					**-10.40**	**0.20**	**6.97**

The range of score calculated by PC analysis is centered around zero with values from -8.12 for the worst performance overall and 5.44 for the best performance overall.[16] In order to simplify the comparison with the fixed weight index, the principal component scores are normalized to range between 0 (worst performance) to 100 (best performance) so,

ISHAI_PC= (PC score-minimum PC score)/Maximum PC score

Finally, in order to see how sensitive the index is to the inclusion/exclusion of one indicator, I ran the analysis removing one indicator at a time; the results were not significantly different.

4.2 Results compared to the fixed weight index results

4.2.1 Overall correlation between the fixed weight and PC index results

Table 8 reports correlation coefficients between all indices and methods. It is apparent that the Principal Components index is very closely related to the Fixed Weight index in the form that is proposed in this report, showing that the fixed weight index, despite its limited number of components and the arbitrariness of the weights assigned to each indicator is a good index. The table also shows that, as for the fixed weight index, equality adjusted numbers closely follow the non-adjusted numbers.

Table 8. Correlation between rankings obtained using FW and PC methods

	ISHAI_FW	ISHAIEQ_FW v=2	ISHAIEQ_FW v=8
ISHAI_PC	**0.9875**	0.9809	0.9443
ISHAIEQ_PC, v=2	0.9788	**0.985**	0.9656
ISHAIEQ_PC, v=8	0.9465	0.9685	**0.9808**

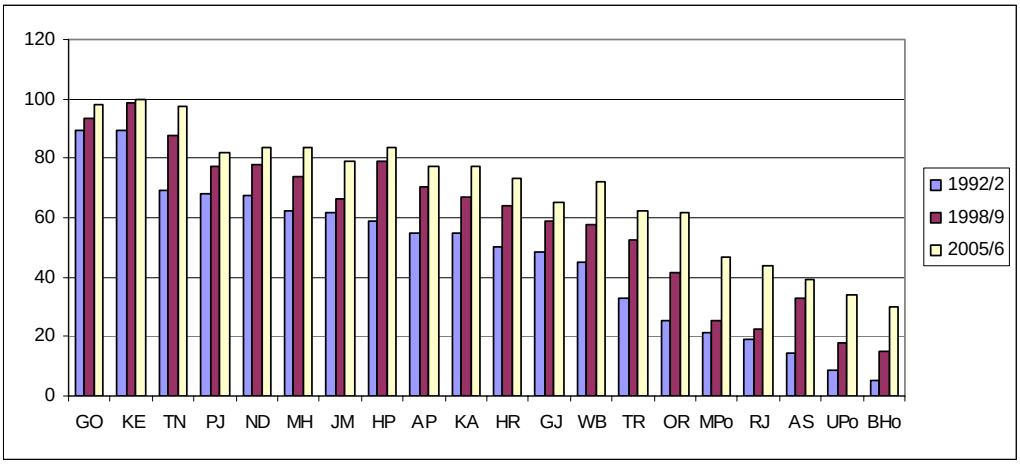
4.2.2 Non Adjusted Index

Full State analysis. Results of the non-adjusted PC based index (ISHAI_PC and ISHAIEQ_PC) for 20 Indian states are presented in Figure 15 and 16. Figure 15 gives values of the ISHAI_PC index and Figure 16 gives the full state rankings. The figures are to be compared to Figures 1 and 2 of the fixed weight analysis.

As expected from the correlation analysis above, results are very similar to the Fixed Weight index. There are a few slight differences on which I will focus here. Since the principal components method is better in terms of capturing a larger dimension of the problem, these differences are important to note. The good news is, the PC index does not show any worsening between 1992 and 1999. Bihar, in particular, although the worst performer overall showed progress every year. The 1998/9 reduced score for Goa also disappears.

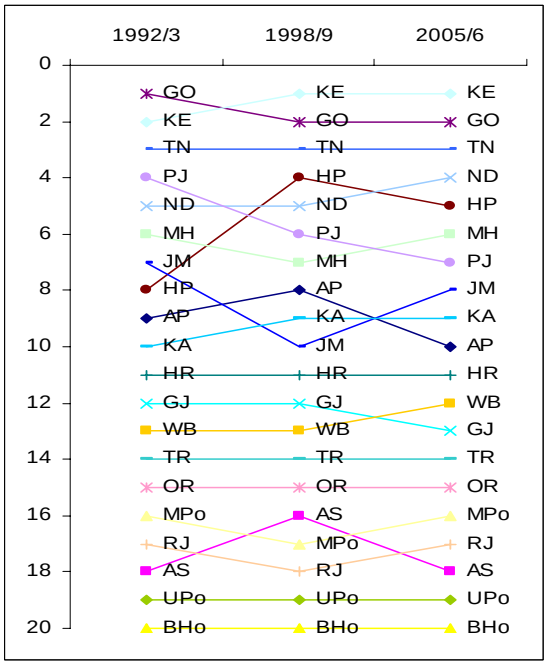
[16] Note that this range is smaller than the range of Table 7 since the worst/best performer overall is not the worst/best performer in every dimension of the index.

Figure 15. Principal Components ISHAI (ISHAI_PC) – 20 Indian States



Rankings and changes in rankings are somewhat altered compared to the fixed weight index. ISHAI_PC shows greater stability in rankings. Overall states kept their ranking at least within the group of 3 states. Two exceptions are Himachal Pradesh and Punjab. HP still shows a significant rise between 1992 and 1999 but its decline in ranking in 2005/6 is much dampened for a net gain of three ranks over the period. Punjab shows the same decline as with the fixed weight method (losng four ranks). Karnakata looks better with the PC method with a gain of one rank over the whole period, overtaking Andhra.

Figure 16. ISHAI_PC: Ranking 1992/3 to 2005/6 – 20 Indian States



Rural vs Urban. As with the fixed weight analysis, the sample of states with non-missing data on all the dimensions of the index is smaller when looking at rural/urban analysis. Figure 17 presents data on 19 states without attempting to give estimates for partially missing data. As before New Delhi is removed from the rural analysis and Tripura from the urban analysis. Ranks are only given to states with full data. As noted before, the distribution is much tighter and shifter upward in urban areas compared to rural areas. All states except urban Andhra Pradesh improved during the period in both rural and urban areas but the improvement is much more pronounced in rural areas, as expected. The index shows little difference overall with the fixed weight index except for urban areas of Andhra Pradesh and Punjab that look worse with the PC index.

Figure 17. ISHAI_PC – Rural India (19 states)

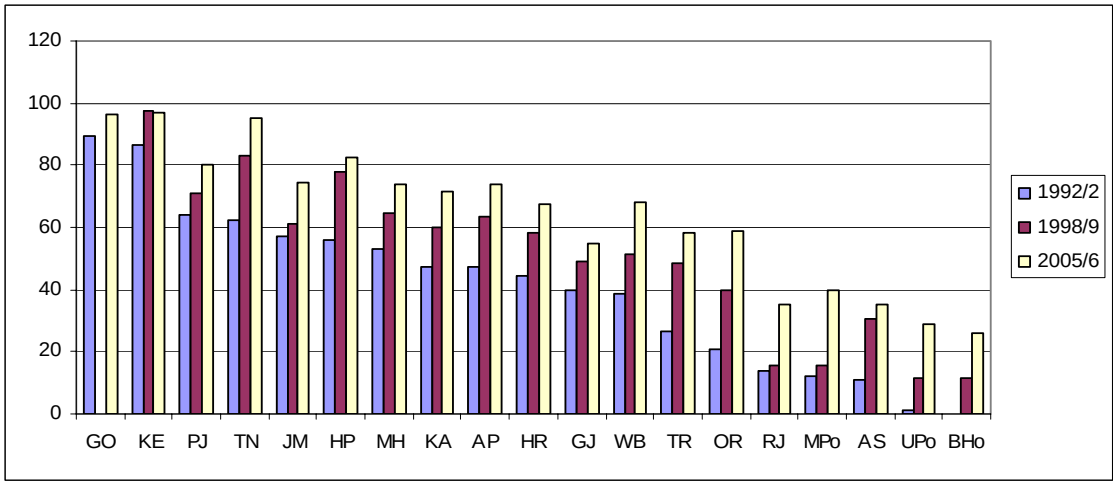


Figure 18. ISHAI_PC – Urban India (19 states)

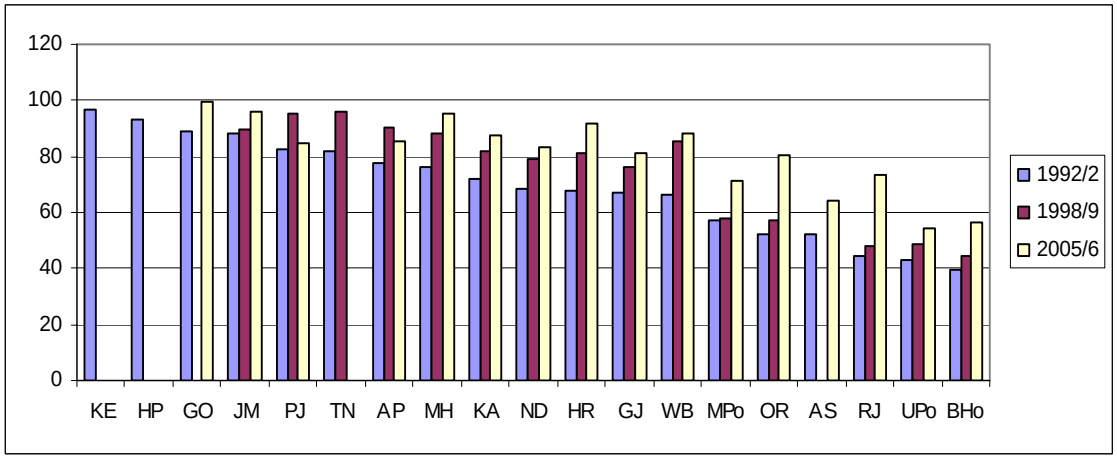


Figure 19. ISHAI_PC: Rankings – Rural India (18 states)

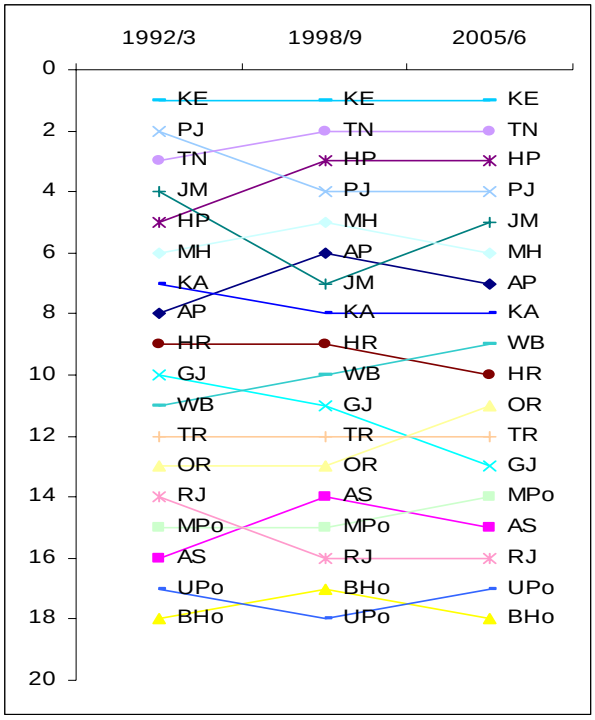
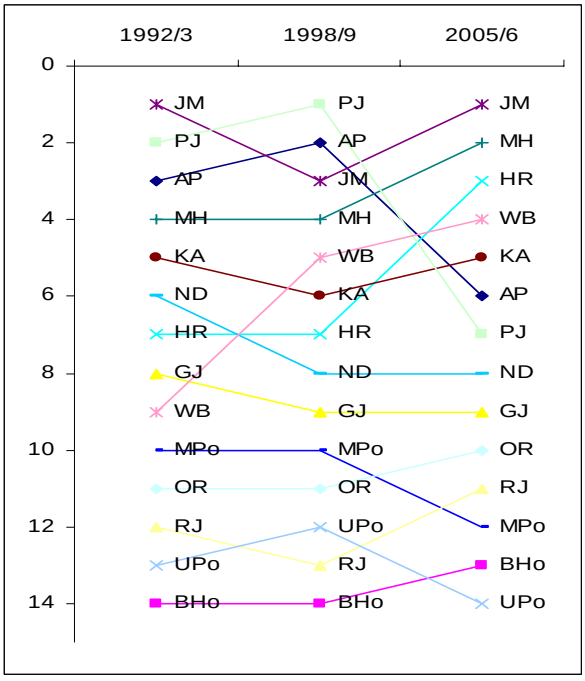


Figure 20. ISHAI_PC: Rankings – Urban India (15 states)



4.2.3 Equality adjusted index (ISHAIEQ_PC)

An equality-adjusted index is estimated with principal components analysis using the exact same method as the non-adjusted index but replacing mean values of the indicators by Wagstaff's extended achievement indices. The index with base level of inequality aversion v=2 and high inequality aversion v=8 are presented and compared to their equivalent fixed weight index. As before, the sample sizes for the urban analysis are too small to report quintile level numbers. Since it is not feasible to compare urban and rural areas and since the index has been shown to resemble closely the fixed weight index so far, only the state-level figures are presented here. The full index is given in the Appendix.

Figures 21 and 22 present results of the Equality Adjusted Principal Component Indian States Health Achievement Index (ISHAI_EQ) for 19 states for two levels of inequality aversion; figures 23 and 24 represent the rankings. As for the non-adjusted index, results are very similar to the fixed weight index (figures 7 to 10). Performances for West Bengal, Madhya Pradesh, Uttar Pradesh, and Bihar look better in the second part of the period than with the fixed weight index at v=2.

Figure 21. Equality Adjusted Principal Component Index (ISHAIEQ_PC) – 19 States – v=2

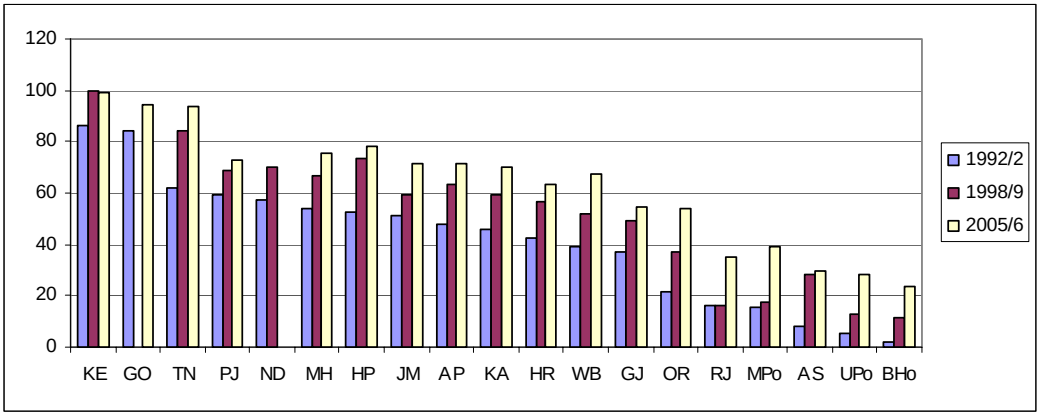
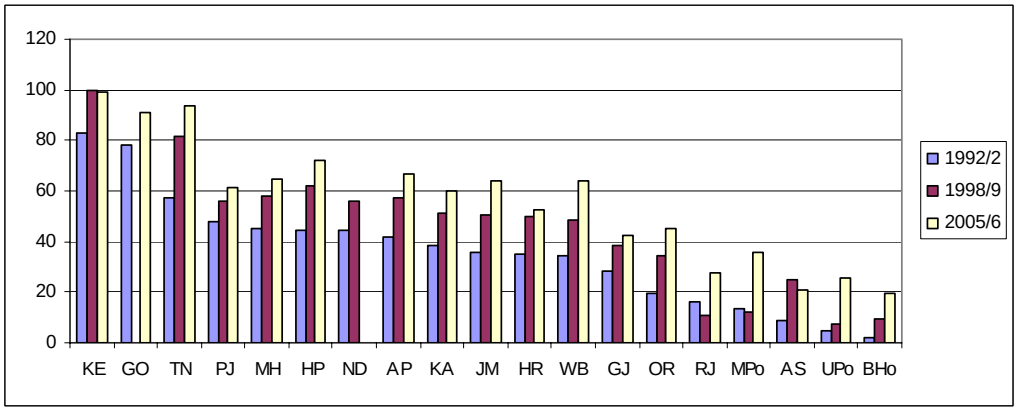


Figure 22. ISHAIEQ_PC– 19 states – v=8



Looking at rankings, the PC index highlights two new features: Punjab looks now much worse in adjusted terms and more so at a high level of inequity aversion while Andhra Pradesh and West Bengal look much better.

Figure 23. ISHAIEQ_PC: Ranking 1992/3 to 2005/6 – 17 States - v=2

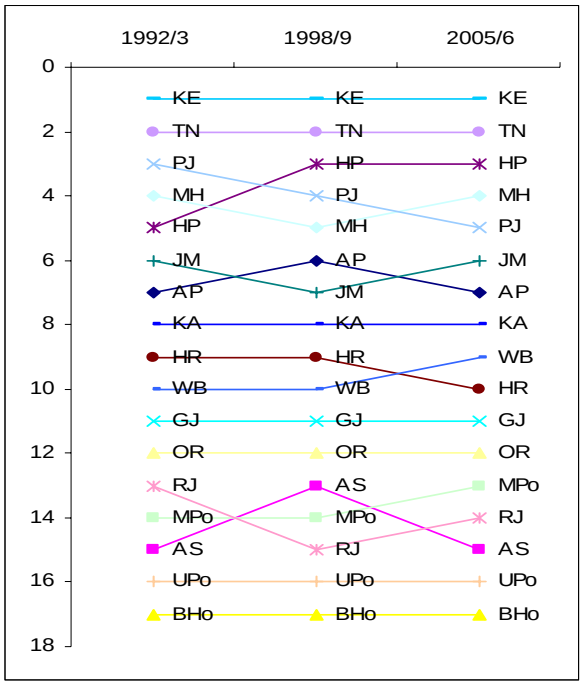
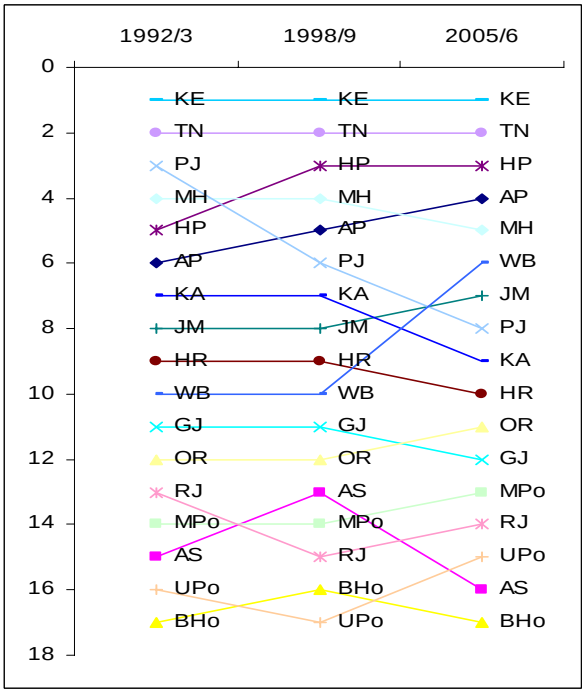


Figure 24. ISHAIEQ_PC: Ranking 1992/3 to 2005/6 – 17 States - v=8



5. CONCLUSIONS

The amount of health data available through Demographic and Health Surveys is very large and it is difficult to get a sense of overall performance looking at each indicator separately. When, in addition, one wants to get a better idea of the distribution of benefits among different income groups and different areas (rural versus urban) one can easily get overwhelmed and miss important information.

Composite indices have been used extensively; the most well know being the UN Human Development Index (HDI). The HDI has generated a lot of writing in terms of its composition, choice of weights and particularly recently, about the superiority of some statistical methods such as principal component analysis or fuzzy set methods that are able to generate weights from the data itself.

I proposed in this report a new index to evaluate achievement in public health for Indian States. I develop the index using two methods: the fixed weight method a la HDI and the Principal Components method. I find that the two methods of calculating the index give very similar results. The results do not present surprises in the ranking of Indian states in health but do give some useful information and incentives to dig deeper into the data to understand why some states have done better or worse than others.

Another task was to transform the index so it would incorporate a measure of the distribution of benefits among different income groups, especially the poor. In order to do so, extended achievement indices were calculated for all indicators based on quintile-specific means and sample sizes. The numbers are based on averages by quintile but weights on each quintile changes depending on the degree of inequality aversion. These numbers were used instead of the simple averages to calculate equity-adjusted indices for different degrees of risk aversion. Although the correlation between non-adjusted and inequality-adjusted indices are very high, a closer look at the data by states reveal some interesting patterns when comparing different degrees of inequality aversion. Overall, one sees that the poor in India have benefited positively but no more than other income groups from health sector achievements, so inequalities have not been reduced. More analysis can be done by comparing indices at different levels of inequality aversion.

The methods and programs developed for this report can easily be used (with some adjustments related to data availability) to create health achievement indices for different countries. While the index itself does not provide information that is directly useful for policy-making, it is a useful tool to quickly identify weaknesses and strengths and guide efforts of the investigator in the right direction.

REFERENCES

Biswas, B. and F. Caliendo (2002). A Multivariate Analysis of the Human Development Index. *Indian Economic Journal* 49(4): pp. 96-100.

Cahill, M. B. and Sanchez, N. (2001). Using Principal Components to Produce an Economic and Social Development Index: An Application to Latin America and the U.S. *Atlantic Economic Journal*

*Cortinovis I, Vela V, Ndiku J. (1993). Construction of a socio-economic index to facilitate analysis of health in data in developing countries. Social Science and Medicine 36: 1087–97.

*Desai, M. (1991). Human Development: Concepts and Measurement. *European Economic Review*, 35 : pp. 350-7.

Gaudin, S. and Yazbeck, A. (2006). Immunization in India 1993-1999: Wealth, Gender, and Regional Inequalities Revisited. *Social Science and Medicine*, 62(3), pp. 694-706

Wagstaff, A. (2002). Inequality aversion, health inequalities and health achievement. *Journal of Health Economics*, 21(4), 627-41.

APPENDIX

Table A-1. State Codes

State code	State
BHn	Bihar – new state (2005/6 data)
Bho	Bihar – old state (until 1999) or reconstituted (for 2005/6 data)
CH	Chhattisgarh (2005/6 data only)
GJ	Gujarat
GO	Goa
HP	Himachal Pradesh
HR	Haryana
JH	Jharkhand (2005/6 data only)
JM	Jammu and Kashmir
KA	Karnataka
KE	Kerala
MH	Maharashtra
MPn	Madhya Pradesh – new state (2005/6 data)
MPo	Madhya Pradesh – old state (until 1999) or reconstituted (for 2005/6 data)
ND	New Delhi
OR	Orissa
PJ	Punjab
RJ	Rajasthan
TN	Tamil Nadu
TR	Tripura
UC	Uttaranchal (2005/6 data only)
UPn	Uttar Pradesh – new state (2005/6 data)
UPo	Uttar Pradesh – old state (until 1999) or reconstituted (for 2005/6 data)
WB	West Bengal

Table A-2. ISHAI_FW *

ID	Iav (index)	Outcomes score	Preventive score	Treatment score
AP21	54.41533	58.11103	56.20567	48.92927
AS21	20.92883	40.2728	11.91233	10.60136
BHo21	21.0594	27.58699	7.439229	28.15199
GJ21	49.67761	51.11456	53.36061	44.55767
GO21	72.77502	73.81114	68.19547	76.31845
HP21	51.91592	59.15198	55.37204	41.22374
HR21	46.57328	53.28432	46.94022	39.49529
JM21	51.90359	58.82026	52.82428	44.06624
KA21	54.59803	53.83228	58.86102	51.10078
KE21	72.66087	68.10721	72.38957	77.48582
MH21	55.31416	53.45839	62.92554	49.55856
MPo21	33.26738	34.37694	26.4604	38.96479
ND21	60.94953	65.26754	65.41686	52.16419
OR21	29.53413	37.21735	30.87437	20.51066
PJ21	62.28801	60.53732	60.94842	65.37828
RJ21	30.04794	49.2467	16.67123	24.22589
TN21	61.28547	60.62517	67.90684	55.32441
TR21	34.63327	43.15941	22.64164	38.09874
UPo21	23.318	26.82992	10.77777	32.3463
WB21	45.41677	44.53086	37.76793	53.95152
AP41	63.36522	59.21148	68.36936	62.51482
AS41	31.63229	56.22703	16.79934	21.87051
BHo41	22.14705	34.59373	7.291247	24.55616
GJ41	54.58052	55.7262	56.62614	51.38921
GO41	71.69823	70.32034	70.54685	74.22749
HP41	67.56269	63.97033	73.77953	64.93822
HR41	59.72054	59.91222	52.54604	66.70338
JM41	55.45464	53.30879	54.64998	58.40514
KA41	60.61167	58.00101	66.08388	57.75012
KE41	78.30611	67.64503	81.93308	85.3402
MH41	62.64292	50.78936	71.96552	65.17389
MPo41	31.2792	31.74812	27.20895	34.88052
ND41	63.96736	58.55047	62.31601	71.0356
OR41	36.84229	41.74718	41.04847	27.73122
PJ41	69.22131	66.10654	64.67973	76.87766
RJ41	32.16721	38.14614	21.14536	37.21014
TN41	73.63233	67.81905	81.39754	71.6804
TR41	46.75176	50.82	41.87753	47.55775
UPo41	25.66031	34.12769	10.30519	32.54805
WB41	48.76912	57.29884	49.68266	39.32588
AP50	72.22044	78.28212	73.24248	65.1367
AS50	37.30148	69.37408	26.30335	16.22701
BHn50	32.97781	46.42477	19.4403	33.06836
BHo50	32.94027	46.17773	21.66753	30.97554
CH50	54.28039	63.87944	51.66468	47.29704
GJ50	60.95884	67.0888	59.59786	56.18984
GO50	78.2011	82.40545	71.1376	81.06024
HP50	71.29426	81.37601	77.66993	54.83684

ID	Iav (index)	Outcomes score	Preventive score	Treatment score
HR50	67.44559	73.6035	65.57463	63.15865
JH50	32.82462	45.4168	28.52786	24.52921
JM50	65.13243	76.52593	62.99591	55.87543
KA50	69.96568	74.11655	71.85821	63.92226
KE50	80.57126	82.33422	81.8308	77.54876
MH50	74.53172	78.18566	72.84002	72.56949
MPn50	44.99854	51.29606	45.59365	38.10591
MPo50	47.38055	54.52535	47.15166	40.46465
ND50	72.53738	80.65382	69.38519	67.57315
OR50	55.20366	66.6859	52.92423	46.00084
PJ50	72.29511	79.70066	67.76044	69.42424
RJ50	45.67318	61.32941	35.24469	40.44543
TN50	81.8463	86.74835	86.18078	72.60977
TR50	54.57596	60.51982	51.97417	51.23389
UC50	55.21971	66.64332	56.28059	42.73521
UPn50	36.35379	53.61729	19.4884	35.95569
UPo50	37.27063	54.25033	21.2764	36.28516
WB50	60.83929	70.50696	60.88611	51.12481
APRur21	49.15306	54.6981	51.08015	41.68093
ASRur21	18.09571	38.22797	8.787787	7.27136
BHoRur21	17.63372	24.65188	3.600867	24.64841
GJRur21	44.1812	46.46621	49.25944	36.81794
GORur21	73.30149	74.45869	69.23622	76.20956
HPRur21	49.81187	57.57068	52.92447	38.94046
HRRur21	42.56428	49.63718	43.34687	34.70877
JMRur21	48.33978	56.05561	48.89249	40.07122
KARur21	49.41228	48.88209	56.43076	42.924
KERur21	70.5	66.26791	71.42363	73.80846
MHRur21	48.84536	47.32001	61.09479	38.12126
MPoRur21	27.56357	27.47626	21.02584	34.1886
NDRur21	56.6697	59.90457	57.8304	52.27412
ORRur21	26.16822	34.06358	27.87617	16.5649
PJRur21	58.66049	56.02973	57.23271	62.71903
RJRur21	26.37773	46.3084	11.01612	21.80868
TNRur21	56.8726	58.05527	65.17189	47.39063
TRRur21	29.93615	40.60208	16.93183	32.27455
UPoRur21	18.65981	22.06173	6.304223	27.61346
WBRur21	40.42967	40.17775	35.02856	46.0827
APRur41	58.7583	56.18646	64.95609	55.13236
ASRur41	30.29094	54.96542	15.04094	20.86648
BHoRur41	20.18711	31.93575	4.890494	23.73509
GJRur41	46.76487	47.7925	52.20632	40.2958
GORur41	74.11265	70.74318	71.19592	80.39884
HPRur41	66.65632	63.69637	72.946	63.3266
HRRur41	56.24526	57.64424	47.92546	63.16608
JMRur41	51.45219	51.15556	48.86814	54.33288
KARur41	55.25185	54.29931	64.6104	46.84584
KERur41	77.55454	65.32854	81.42685	85.90824
MHRur41	55.20535	44.64995	69.61659	51.34952
MPoRur41	24.35486	26.47854	20.64372	25.94231

ID	Iav (index)	Outcomes score	Preventive score	Treatment score
NDRur41	53.06855	50.36846	60.64229	48.19489
ORRur41	35.22871	40.62197	39.48313	25.58101
PJRur41	65.63247	62.51016	59.47366	74.91358
RJRur41	27.43547	34.14486	16.28853	31.87304
TNRur41	69.87879	66.04569	77.31861	66.27208
TRRur41	44.41096	50.02975	38.63086	44.57229
UPoRur41	21.16946	29.32354	5.59324	28.59159
WBRur41	44.16298	54.4766	46.60614	31.40621
APRur50	71.5929	75.61817	71.2646	67.8959
ASRur50	34.50694	67.5094	23.37491	12.63652
BHnRur50	30.57915	44.14999	16.63408	30.9534
BHoRur50	29.51599	42.86103	17.47889	28.20805
CHRur50	49.40633	59.78746	45.64465	42.78688
GJRur50	53.78676	61.35912	53.20506	46.79609
GORur50	78.21047	79.81628	67.87385	86.94128
HPRur50	70.28227	80.41492	76.88893	53.54297
HRRur50	62.99425	70.26395	61.45541	57.26339
JHRur50	25.84078	38.40528	20.39931	18.71775
JMRur50	61.56327	74.18339	57.87316	52.63326
KARur50	66.83007	70.94321	69.80086	59.74613
KERur50	79.53202	80.2605	78.97346	79.36209
MHRur50	67.1632	73.23897	65.56873	62.6819
MPnRur50	40.60379	47.64412	39.38395	34.78328
MPoRur50	42.9801	50.92231	41.07407	36.94392
NDRur50		74.96091		
ORRur50	52.47324	64.4977	51.17702	41.745
PJRur50	71.85352	78.04352	67.06549	70.45154
RJRur50	38.47291	57.38048	26.18688	31.85138
TNRur50	81.94138	82.25081	87.03621	76.53712
TRRur50	51.62284	58.31107	50.1922	46.36525
UCRur50	50.29552	62.94969	51.14696	36.7899
UPnRur50	32.17789	50.22706	14.53858	31.76803
UPoRur50	33.02258	50.82022	16.24535	32.00216
WBRur50	57.39074	67.43015	57.73914	47.00294
APUrb21	69.73746	68.44653	70.2047	70.56116
ASUrb21	47.36365	57.83844	39.73983	44.51268
BHoUrb21	43.70512	45.8605	31.94786	53.30701
GJUrb21	61.91175	60.72405	61.66914	63.34206
GOUrb21	72.18298	72.95214	67.10561	76.49121
HPUrb21	77.14419	75.12148	82.08944	74.22164
HRUrb21	59.60448	63.94029	58.54718	56.32595
JMUrb21	72.02812	72.91731	75.09299	68.07406
KAUrb21	67.54192	65.30163	64.38377	72.94034
KEUrb21	79.3646	72.84275	74.99182	90.25923
MHUrb21	65.41818	62.4371	65.83138	67.98606
MPoUrb21	54.86386	59.50985	46.98038	58.10135
NDUrb21	61.42796	65.64256	66.105	52.53633
ORUrb21	49.57671	54.65189	48.26186	45.81637
PJUrb21	74.03458	74.01004	72.38643	75.70725
RJUrb21	47.18627	61.70056	43.17774	36.6805

ID	Iav (index)	Outcomes score	Preventive score	Treatment score
TNUrb21	69.31024	65.37659	72.84317	69.71097
TRUrb21				
UPoUrb21	44.53598	46.3792	31.41422	55.81451
WBUrb21	61.08669	56.86949	47.39638	78.99421
APUrb41	76.90157	68.37598	78.59366	83.73509
ASUrb41	46.06344	74.47238	34.07099	29.64694
BHoUrb41	41.00957	59.58997	31.11136	32.32737
GJUrb41	68.35934	68.30038	64.25822	72.51944
GOUrb41	69.22393	70.51914	69.21924	67.93342
HPUrb41	78.05491	66.64898	84.42226	83.09348
HRUrb41	70.30366	65.97934	66.67957	78.25206
JMUrb41	73.66514	61.11298	79.93361	79.94882
KAUrb41	72.80648	65.95702	69.30321	83.15922
KEUrb41	81.30009	76.56352	83.83698	83.49977
MHUrb41	73.7001	60.20762	75.85709	85.03557
MPoUrb41	54.42513	49.32773	49.30251	64.64516
NDUrb41	65.16994	59.45507	62.4604	73.59436
ORUrb41	50.71716	51.06536	54.46751	46.61861
PJUrb41	79.8119	75.81899	79.83881	83.77791
RJUrb41	49.44727	51.71244	38.50659	58.12276
TNUrb41	80.66884	71.28854	89.0088	81.70917
TRUrb41				
UPoUrb41	46.96795	54.85653	32.15198	53.89534
WBUrb41	70.38503	68.79859	64.17731	78.17921
APUrb50	74.98261	83.73686	76.89265	64.31833
ASUrb50	55.79472	79.19477	43.3757	44.8137
BHnUrb50	48.89346	59.27824	38.62637	48.77579
BHoUrb50	52.71655	63.05015	45.12964	49.96986
CHUrb50	75.65063	80.98224	78.07008	67.89957
GJUrb50	72.50912	75.56213	69.92775	72.03748
GOUrb50	78.0088	84.49961	73.79547	75.73132
HPUrb50	79.50745	88.33148	82.60134	67.58954
HRUrb50	81.14108	82.51547	77.83776	83.07002
JHUrb50	60.19571	70.4292	57.85209	52.30585
JMUrb50	76.726	83.08619	78.18471	68.90709
KAUrb50	75.31697	79.57737	75.18364	71.1899
KEUrb50	82.71151	86.43054	87.83172	73.87226
MHUrb50	83.04678	83.64712	80.70697	84.78627
MPnUrb50	59.48222	62.14173	65.08563	51.2193
MPoUrb50	62.99178	66.23131	67.90407	54.83997
NDUrb50	71.82878	81.09216	69.38749	65.00668
ORUrb50	71.9043	78.6791	62.44831	74.58548
PJUrb50	73.05091	82.55041	69.23454	67.36778
RJUrb50	68.47532	72.097	65.13898	68.18997
TNUrb50	80.64422	92.61112	85.23705	64.0845
TRUrb50				82.00021
UCUrb50	70.37885	77.72881	71.40398	62.00377
UPnUrb50	51.39104	64.52925	37.09597	52.5479
UPoUrb50	52.42968	65.25127	38.97263	53.06514
WBUrb50	72.15979	78.85301	72.06036	65.56599

*highlighted are approximated using partial data

Table A-3. ISHAI_FWEQ v=2 and v=8

ID	ISHAIEQ 2	Out	Prevent	Treat	ISHAIEQ 8	Out	Prevent	Treat
AP21	48.12	55.17	50.91	38.28	44.35	54.44	43.30	35.31
AS21	14.45	35.63	5.85	1.87	15.83	40.20	2.62	4.68
BHo21	16.43	25.39	3.76	20.14	17.08	24.77	3.45	23.02
GJ21	40.75	44.64	46.13	31.46	34.63	41.05	36.24	26.61
GO21	69.27	70.41	67.29	70.09	65.25	67.92	61.02	66.79
HP21	46.69	56.20	49.65	34.21	43.26	52.91	43.65	33.21
HR21	41.00	50.33	40.15	32.53	37.50	45.73	32.34	34.44
JM21	43.20	54.61	43.08	31.92	33.23	46.37	28.35	24.97
KA21	46.68	49.56	53.14	37.34	40.44	47.57	46.17	27.57
KE21	70.51	67.83	72.43	71.27	68.19	67.37	68.43	68.77
MH21	47.29	48.15	58.52	35.21	40.67	43.06	53.23	25.73
MPo21	27.22	31.57	20.64	29.44	25.81	34.18	16.94	26.30
ND21	53.36	58.77	57.37	43.96	43.18	52.16	42.33	35.04
OR21	24.62	34.63	27.23	11.99	25.29	36.24	24.91	14.72
PJ21	55.79	54.97	53.47	58.92	48.31	50.16	42.57	52.21
RJ21	25.87	49.40	11.98	16.21	27.64	51.80	9.04	22.08
TN21	55.20	57.89	65.15	42.57	51.49	57.09	59.23	38.14
TR21				26.48				27.44
UPo21	19.49	24.30	7.90	26.27	19.29	24.40	6.62	26.84
WB21	40.17	39.96	34.37	46.19	37.61	42.18	32.21	38.45
AP41	56.47	57.24	63.51	48.65	50.71	58.16	56.73	37.26
AS41	27.51	54.34	13.25	14.93	28.22	54.86	11.05	18.76
BHo41	17.12	30.97	3.68	16.72	16.89	32.05	1.35	17.29
GJ41	46.03	49.28	50.65	38.17	37.88	44.10	40.42	29.13
GO41				67.07				60.58
HP41	63.18	63.47	68.92	57.14	56.94	60.60	57.98	52.24
HR41	53.49	55.04	46.82	58.62	48.30	52.12	39.78	53.00
JM41	48.68	50.28	46.12	49.62	42.40	50.13	33.86	43.21
KA41	54.21	54.95	61.25	46.42	49.02	55.14	52.20	39.73
KE41	77.58	67.65	83.66	81.44	75.53	64.47	83.79	78.34
MH41	55.22	46.72	67.17	51.76	47.41	46.15	57.85	38.25
MPo41	23.11	27.26	20.13	21.95	21.10	29.17	15.07	19.06
ND41	56.58	52.88	56.82	60.03	45.38	50.04	40.99	45.11
OR41	31.41	38.68	36.99	18.56	32.22	42.23	33.18	21.26
PJ41	62.74	61.50	57.86	68.87	52.31	58.24	46.41	52.28
RJ41	25.65	34.22	15.48	27.25	22.62	30.76	11.23	25.89
TN41	68.96	65.98	79.04	61.85	64.25	63.01	74.23	55.49
TR41				38.20				28.05
UPo41	19.83	29.39	6.28	23.81	17.76	25.32	4.22	23.75
WB41	42.58	53.88	46.03	27.82	40.59	53.80	39.46	28.49
AP50	67.22	75.24	69.58	56.83	62.68	72.06	63.86	52.13
AS50	29.79	64.09	19.70	5.59	25.76	60.36	9.72	7.19
BHn50	27.15	42.75	13.08	25.60	24.23	40.57	7.76	24.35
BHo50	26.31	41.92	14.74	22.28	23.58	40.20	9.72	20.83

ID	ISHAIEQ 2	Out	Prevent	Treat	ISHAIEQ 8	Out	Prevent	Treat
CH50	49.15	61.25	44.44	41.78	47.60	61.85	37.03	43.92
GJ50	52.55	61.84	53.12	42.70	43.51	56.74	42.59	31.21
GO50	75.15	80.66	70.68	74.10	72.92	79.67	66.83	72.25
HP50	66.47	80.27	73.53	45.59	63.38	80.77	65.60	43.76
HR50	59.77	69.77	58.93	50.61	49.51	64.96	47.39	36.18
JH50	23.75	39.39	19.84	12.03	21.61	39.09	15.76	9.98
JM50	58.05	73.89	56.79	43.49	51.59	72.49	46.28	36.01
KA50	64.71	71.75	67.52	54.86	58.68	69.22	55.55	51.25
KE50	79.40	81.84	82.62	73.74	79.59	80.64	82.06	76.08
MH50	68.10	74.92	67.16	62.22	61.01	71.30	56.53	55.20
MPn50	38.33	47.04	38.83	29.11	38.55	47.42	33.85	34.37
MPo50	41.11	50.69	40.27	32.36	40.87	51.13	34.66	36.82
ND50	64.88	77.40	58.97	58.27	53.25	73.42	45.32	41.01
OR50	47.26	62.91	47.09	31.76	40.06	61.83	37.64	20.70
PJ50	66.52	76.21	61.42	61.93	61.15	73.41	48.54	61.52
RJ50	37.10	58.87	26.86	25.55	31.19	57.09	18.58	17.89
TN50	79.11	84.41	86.19	66.74	75.12	82.55	86.22	56.58
TR50				41.18				31.53
UC50	45.50	61.48	47.21	27.79	37.92	57.99	36.87	18.91
UPn50	31.14	50.91	14.49	28.03	29.77	49.33	10.93	29.05
UPo50	31.84	51.42	16.08	28.02	30.17	49.75	12.19	28.56
WB50	55.63	67.84	57.57	41.49	51.11	69.21	50.98	33.14
APRur21	45.22	52.91	48.66	34.11	43.77	53.17	44.29	33.85
ASRur21	13.43	34.22	4.82	1.24	14.89	37.02	2.94	4.70
BHoRur21	14.96	24.18	2.25	18.44	15.00	24.91	2.15	17.95
GJRur21	37.16	42.19	43.64	25.64	33.41	38.45	38.07	23.72
GORur21	72.11	71.81	69.11	75.42	64.03	69.26	44.03	78.81
HPRur21	45.24	54.41	48.33	32.98	42.86	51.30	41.97	35.30
HRRur21	39.55	48.60	38.90	31.15	37.65	45.07	33.09	34.80
JMRur21	40.48	52.35	39.95	29.14	31.49	44.43	26.62	23.44
KARur21	43.85	46.70	52.73	32.13	40.78	46.18	47.30	28.86
KERur21	68.31	66.33	71.95	66.65	67.00	65.28	69.50	66.21
MHRur21	42.49	42.80	57.63	27.02	36.93	38.68	50.78	21.34
MPoRur21	24.94	28.83	18.32	27.67	25.17	33.37	15.52	26.62
NDRur21								
ORRur21	23.61	33.58	26.47	10.77	26.73	37.06	26.33	16.80
PJRur21	53.41	51.19	51.39	57.65	47.61	48.67	41.50	52.68
RJRur21	24.32	48.68	9.53	14.74	26.76	51.40	7.46	21.41
TNRur21	51.37	56.21	62.41	35.48	48.66	57.96	57.42	30.59
TRRur21				22.55				24.92
UPoRur21	17.35	21.95	6.17	23.94	17.46	23.63	5.79	22.96
WBRur21	37.26	37.88	32.77	41.12	36.30	38.49	31.51	38.88
APRur41	53.33	55.18	60.84	43.96	50.19	57.32	57.04	36.22
ASRur41	26.80	53.66	12.47	14.26	27.44	53.64	10.45	18.23
BHoRur41	16.14	29.60	2.43	16.40	16.47	31.64	1.17	16.60
GJRur41	40.93	43.62	47.99	31.18	36.68	41.23	40.41	28.40
GORur41				73.03				77.31
HPRur41	62.37	62.85	68.11	56.16	56.01	58.87	57.47	51.69
HRRur41	51.85	53.87	44.73	56.95	46.22	50.56	37.49	50.61
JMRur41	46.11	48.92	42.05	47.37	40.85	47.30	32.89	42.35

ID	ISHAIEQ 2	Out	Prevent	Treat	ISHAIEQ 8	Out	Prevent	Treat
KARur41	50.86	52.11	59.49	40.98	47.50	53.79	50.84	37.85
KERur41	76.33	65.29	83.56	80.14	73.86	62.79	83.71	75.07
MHRur41	48.33	41.73	63.73	39.53	41.53	40.56	52.86	31.17
MPoRur41	19.43	25.23	16.98	16.07	20.21	30.58	14.24	15.81
NDRur41								
ORRur41	31.05	38.02	36.86	18.26	33.36	41.92	35.05	23.10
PJRur41	60.07	58.39	53.87	67.95	51.27	55.90	43.39	54.53
RJRur41	22.94	31.01	13.40	24.41	21.28	26.58	10.83	26.43
TNRur41	66.02	64.41	76.05	57.58	62.73	62.40	72.20	53.60
TRRur41				35.71				31.59
UPoRur41	17.99	26.72	4.24	23.02	17.63	22.13	4.43	26.32
WBRur41	40.18	52.64	43.65	24.25	40.47	52.51	38.36	30.53
APRur50	67.44	72.85	68.90	60.57	64.55	72.41	65.95	55.29
ASRur50	28.22	62.51	17.34	4.80	26.07	58.92	8.98	10.32
BHnRur50	26.10	41.55	11.83	24.91	24.30	40.26	6.90	25.73
BHoRur50	24.78	40.22	12.76	21.37	22.82	38.90	8.18	21.38
CHRur50	47.49	59.29	41.70	41.49	45.66	62.26	36.80	37.93
GJRur50	45.88	56.96	47.58	33.09	39.21	54.65	38.44	24.56
GORur50	77.41	78.32	69.44	84.48	72.17	78.33	63.02	75.17
HPRur50	65.41	79.67	72.78	43.79	61.81	79.78	64.58	41.06
HRRur50	55.81	67.27	55.66	44.50	45.11	60.40	42.39	32.52
JHRur50	20.23	35.60	15.96	9.12	17.72	34.21	12.63	6.32
JMRur50	56.63	73.62	52.99	43.27	52.58	73.79	45.54	38.39
KARur50	63.08	70.54	65.79	52.91	59.86	70.46	55.15	53.99
KERur50	78.96	79.46	79.69	77.74	79.06	79.11	79.47	78.60
MHRur50	61.83	70.69	61.09	53.71	59.83	67.15	54.53	57.82
MPnRur50	36.92	45.18	35.85	29.72	40.42	47.89	34.37	38.99
MPoRur50	39.77	48.99	37.43	32.90	41.83	51.77	35.02	38.71
NDRur50								
ORRur50	45.46	61.72	45.81	28.85	39.38	60.75	38.68	18.72
PJRur50	67.33	75.58	61.57	64.82	61.90	73.96	50.90	60.83
RJRur50	33.10	56.22	22.62	20.47	31.37	56.55	18.14	19.42
TNRur50	77.70	81.18	86.25	65.68	75.63	80.24	86.37	60.28
TRRur50								
UCRur50	42.03	59.25	43.35	23.51	36.65	57.22	36.45	16.29
UPnRur50	29.17	48.34	11.86	27.30	28.76	45.57	10.06	30.66
UPoRur50	29.77	48.85	13.33	27.12	29.13	46.11	11.29	29.99
WBRur50	52.99	65.79	54.96	38.21	49.26	66.69	50.25	30.83
APUrb21				60.98				49.90
ASUrb21								
BHoUrb21				45.42				39.20
GJUrb21			53.91	55.14			39.05	44.12
GOUrb21				64.58				48.91
HPUrb21								
HRUrb21				44.58				29.44
JMUrb21				58.35				39.39
KAUrb21		58.69		63.93		54.96		50.65
KEUrb21				87.79				82.08
MHUrb21		57.57		55.91		56.31		42.19
MPoUrb21		54.73		46.26		50.92		38.94

ID	ISHAIEQ 2	Out	Prevent	Treat	ISHAIEQ 8	Out	Prevent	Treat
NDUrb21	53.64	59.10	57.96	43.85	43.12	52.45	43.22	33.68
ORUrb21				35.21				28.81
PJUrb21								
RJUrb21				24.07				17.55
TNUrb21		62.06		63.20		56.60		60.89
TRUrb21								
UPoUrb21	37.54	41.68	23.38	47.56	31.67	36.83	14.12	44.05
WBUrb21								
APUrb41				76.18				68.44
ASUrb41								
BHoUrb41				22.64				20.20
GJUrb41				61.52				45.72
GOUrb41								
HPUrb41								
HRUrb41				65.34				46.81
JMUrb41				72.72				64.29
KAUrb41				74.33				57.07
KEUrb41								
MHUrb41	68.66	56.37	71.04	78.58	61.69	56.15	58.81	70.12
MPoUrb41	44.81	40.49	39.40	54.53	34.05	32.20	25.95	44.01
NDUrb41	57.69	53.32	57.25	62.51	44.79	48.71	40.90	44.75
ORUrb41								
PJUrb41								
RJUrb41		47.07		50.47		44.77		37.55
TNUrb41			89.03	74.79			84.81	68.86
TRUrb41								
UPoUrb41	37.96	48.03	24.85	41.02	27.94	41.10	15.72	27.02
WBUrb41				65.95				43.16
APUrb50				54.00				37.39
ASUrb50								
BHnUrb50				33.61				23.20
BHoUrb50				34.26				19.97
CHUrb50				60.03				54.53
GJUrb50				65.29				58.55
GOUrb50				65.99				61.29
HPUrb50								
HRUrb50				80.25				71.37
JHUrb50				35.52				13.67
JMUrb50				62.04				50.90
KAUrb50			70.39	59.99			59.94	44.86
KEUrb50								
MHUrb50	79.18	82.03	77.48	78.03	74.24	81.99	70.59	70.13
MPnUrb50				35.97				21.36
MPoUrb50				41.19				28.56
NDUrb50				54.92				38.55
ORUrb50				68.65				65.39
PJUrb50				56.56				54.75
RJUrb50				54.43				36.17
TNUrb50		89.45		60.27		87.28		62.26
TRUrb50								

ID	ISHAIEQ 2	Out	Prevent	Treat	ISHAIEQ 8	Out	Prevent	Treat
UCUrb50				51.54				40.52
UPnUrb50	42.55	59.10	28.16	40.38	33.67	55.31	17.38	28.32
UPoUrb50	43.44	60.40	28.92	40.99	34.63	56.72	18.18	28.99
WBUrb50				55.51				45.90

Table A-4. ISHAI_PC

	Full State			Rural areas			Urban areas		
ID	pciav	pciw2	pciw8	pciav	pciw2	pciw8	pciav	pciw2	pciw8
AP21	54.86	47.66	41.90	47.09	43.40	40.65	77.66		
AS21	14.68	8.38	8.71	10.72	6.73	7.22	52.43		
BHo21	5.18	2.31	2.13	0.00	0.00	0.00	39.68		
GJ21	48.52	37.02	28.05	40.07	32.28	27.83	66.85		
GO21	89.32	84.20	78.40	89.66			88.99		
HP21	58.94	52.51	44.72	56.04	50.64	44.29	92.87		
HR21	50.02	42.61	34.79	44.47	40.29	34.96	68.06		
JM21	61.76	51.38	35.62	57.18	47.63	33.40	88.30		
KA21	54.52	45.60	38.74	47.35	42.10	38.57	71.99		
KE21	89.14	86.59	83.18	86.51	84.45	82.43	96.80		
MH21	62.27	53.70	45.45	53.31	47.18	40.35	76.12		
MPo21	21.49	15.27	13.81	12.11	11.70	12.45	57.37		
ND21	67.63	56.97	44.29				68.43	57.55	44.77
OR21	25.21	21.74	19.65	20.59	19.99	20.25	52.44		
PJ21	68.33	59.21	47.82	63.75	55.90	45.82	82.72		
RJ21	18.78	15.90	16.01	13.64	14.05	14.53	44.46		
TN21	69.07	62.22	57.39	62.02	56.60	53.45	81.79		
TR21	33.07			26.82					
UPo21	8.51	5.49	4.41	1.03	2.13	1.98	43.21	34.96	26.39
WB21	45.14	39.09	34.66	38.65	35.48	32.93	66.06		
AP41	70.17	63.69	57.44	63.53	59.20	55.62	90.02		
AS41	32.69	28.29	25.20	30.52	27.00	23.97			
BHo41	14.82	11.38	9.37	11.83	9.70	8.57	44.72		
GJ41	58.88	49.34	38.21	48.82	41.99	34.40	76.31		
GO41	93.27								
HP41	79.02	73.42	61.84	78.00	72.29	59.96			
HR41	63.85	56.57	49.77	58.20	53.78	45.75	81.20		
JM41	66.23	59.56	50.29	61.31	56.30	48.19	89.71		
KA41	66.98	59.51	51.15	60.14	55.14	50.37	82.23		
KE41	98.92	100.00	100.00	97.54	98.21	97.41			
MH41	73.83	67.02	57.88	64.47	58.97	50.75	88.22	83.60	75.13
MPo41	25.18	17.40	12.04	15.67	12.71	11.05	57.96	46.74	31.30
ND41	77.92	70.27	55.72	65.10			79.31	71.53	54.85
OR41	41.69	37.15	34.52	39.89	36.67	36.45	57.17		
PJ41	77.25	69.04	55.84	71.12	64.20	52.92	95.18		
RJ41	22.47	16.24	10.46	15.61	12.56	8.65	47.83		
TN41	87.83	84.08	81.44	83.33	81.09	79.92	96.33		
TR41	52.60			48.66					
UPo41	17.72	12.63	7.58	11.28	9.65	6.74	49.01	39.86	27.59
WB41	57.51	51.67	48.31	51.47	48.42	46.81	85.66		

AP50	77.26	71.17	66.90	73.63	70.21	69.61	85.12		
AS50	39.15	29.88	20.71	35.45	27.37	19.59	64.25		
BHn50	29.82	23.80	19.28	26.94	22.43	18.46	49.40		
BHo50	30.15	23.45	19.41	25.72	21.48	17.87	56.15		
CH50	55.75	48.94	45.69	48.45	46.06	45.28	88.62		
GJ50	65.06	54.69	42.29	55.08	45.61	36.72	81.24		
GO50	98.18	94.71	90.99	96.11			99.78		
HP50	83.87	78.08	72.47	82.51	76.65	69.85			
HR50	73.35	63.60	52.60	67.35	58.84	47.00	91.88		
JH50	31.16	22.39	19.81	21.52	18.20	15.84	69.35		
JM50	79.25	71.35	63.89	74.66	69.68	66.31	95.75		
KA50	77.49	69.87	59.98	71.51	66.34	60.01	87.66		
KE50	100.00	98.99	99.11	97.12	96.57	97.08			
MH50	83.74	75.28	64.68	73.66	66.04	57.88	95.32	90.43	86.89
MPn50	43.56	35.33	32.42	36.38	32.11	35.12	66.61		
MPo50	46.68	38.83	35.82	39.64	35.88	37.87	71.39		
ND50	83.91						83.52		
OR50	61.69	53.62	45.47	58.58	51.51	44.52	80.62		
PJ50	81.72	72.63	61.58	80.05	72.17	61.74	84.74		
RJ50	43.78	34.86	27.52	35.12	30.25	26.66	73.18		
TN50	97.42	93.86	93.61	95.30					
TR50	62.27			58.31					
UC50	60.12	48.24	36.53	53.46	43.57	35.24	80.75		
UPn50	32.91	27.58	25.15	27.53	24.17	22.11	52.77	42.42	32.66
UPo50	34.23	28.59	25.70	28.74	25.07	22.72	54.30	43.38	33.46
WB50	72.35	67.34	64.08	67.81	64.24	62.80	88.14		