APPENDIX – 1

MEASUREMENT OF HEALTH OUTCOMES

PART-1

Measurement of morbidity

Morbidity rates can pertain to grouped data or individual data. They can be measured clinically, by utilization of health care services or by self-assessment.

Subjective measures

The measures of health obtained by eliciting responses from the people themselves are called subjective measures of health. The subjective measures of health are considered to be the most robust measures of health. They amplify the data obtainable from mortality and morbidity statistics by describing the quality rather than merely the quantity of survival. However, these subjective measures need special statistical and psychometric treatment because they are not inherently quantitative and some sort of numerical scaling technique is required to translate statements about health like, feeling severe pain, into a suitable quantitative form, which would be amenable to statistical analysis. The use of scaling techniques permits subjective health measurements to rival the quantitative strengths of the traditional mortality indicators (McDowell & Newell 1996).

Health status measures can be separated into four genres: (1) generic v/s disease specific, (2) preference based v/s non-preference based, (3) individual v/s population measures of health and, (4) health state descriptions v/s evaluations of change overtime.

Generic measures tap a broad spectrum of health concepts and are intended to be appropriate for groups differing in disease, severity and comorbidity.

Disease specific measures are designed to be applicable to specific patient populations, usually defined by disease pathology. Measurement priorities are focused on aspects of
disease specific health status that are likely to be sensitive to treatment and natural history.

Preference based measures are weighted assessments of health states values with life years, which yield a single aggregate score. The values for health states are obtained under the framework of utility theory.

Non-Preference based measures are also weighted assessments of health state values which are aggregated into a single score. But they are distinct from the preference-based measures because the values for health states are obtained irrespective of any underlying utility theory framework.

Individual health measures as the name suggests are micro measures of health outcomes for each individual.

Population health measures are the measures of health that are aggregated over the entire population.

Theoretical framework for measurement of health index

A health index is a summary measure that can characterize the health of an individual or a group of individuals. It incorporates within itself both qualitative and quantitative dimensions of health. On the qualitative side health has diverse attributes. Therefore the health indices are so constructed that they combine the diverse aspects of health as well as the quantitative valuation of health to represent the composite status of health.

Two steps are involved in the measurement of an index of health. Firstly, we need to develop a health state classification system and secondly, we need to find a method for computing a summary score for this description.
Creation of a health-state classification system

The creation of a health-state classification system depends upon the meaning of health and the attributes of health that should be included in its measurement.

Health as a multiattribute phenomenon

Several dimensions can be adduced to health such as physical, mental, cognitive, social, economic or environmental factors (Wilkin 1987). These diverse attributes of health may possibly be nested hierarchically. A global health index can be created that is a single aggregate summary measure of this multidimensional concept of health.

Each different health state has a potential value associated with it, which is referred to in the literature, as a weight or cardinal value (i.e. having interval or ratio properties).

Combinations of levels of attributes are then subjected to a scaling procedure to produce an index of cardinal values for all possible combinations of levels within the health state classification system.

Scaling of health states

The arrangement of qualitative descriptions of data on a measurement scale having some real number properties is known as scaling. In the measurement of health state values, the need for scaling arises because we need to arrange the several descriptions on health states on a continuum of measurement where the true health itself is unobserved.

Scaling procedures for obtaining health state values

Scaling methods

The scaling methods for determining the types of scale for valuation of health states can be divided into two broad groups. One category of scales are based upon psychometrics and test theory. While the other category of scales are based upon decision theory.
Psychometric scaling measures are based upon classical measurement theory and decision theoretic scales are based upon utility theory.

If the health state valuations are obtained through the use of psychometric theory then we get generic non preference based health values. While, on the other hand, if health state values are obtained through the use of scaling techniques rooted in decision theory then we get generic preference based health status measures.

Before actual scaling is undertaken, the following issues need to be settled:
1. scaling stimuli v/s scaling persons
2. scaling verifiable v/s non verifiable stimuli
3. levels of measurement produced by various scaling methods.
4. direct v/s indirect scaling methods.
5. Whose values?
6. Holistic scaling v/s decomposed scaling.

**Scaling stimuli v/s scaling persons**

In the context of health, when we rate the set of health states we are scaling the stimuli. On the other hand, when we are scaling persons, we rate them on the basis of their responses to an instrument that measures health status.

**Verifiable v/s non verifiable stimuli**

Can the subjective scale be compared to some external standard of accuracy or not?

**Levels of measurement**

The scales can produce any one of the four types of measurement levels viz., nominal, ordinal, interval or ratio. One has to choose the level of measurement depending upon the purpose for which health status measure is going to be used.

**Direct v/s indirect scaling**

In direct scaling, respondents are instructed to make judgements at a certain level of measurement (i.e. interval or ratio) and the resulting data are treated as such. In indirect scaling, respondents are instructed to make judgements at a certain level of measurement (cardinal or ordinal) and the data are later converted to a different level of measurement.
Whose values

While eliciting values of health states whose values should be chosen. Values may be elicited from the patients, from general population, from physicians, policy makers.

Holistic scaling v/s decomposed scaling

One can choose between a holistic and a decomposed approach to scaling.

Holistic approach requires judges to assign values to each possible health state, which may be mentioned, by the scaling method. The category rating method used by Patrick, Bush and Chen (1973) and the Time Trade Off method used by Sackett & Torrance (1978) are examples of holistic scaling methods.

Decomposed approach enables investigators to obtain values for all health states without requiring the judge to assign values to each state. This is done by expressing overall value of a health state as a decomposed function of the attributes. Two types of decomposed scaling designs exist in the literature:

1. Statistically inferred models and
2. Explicitly decomposed models.

Statistically inferred models consist of algebraic models of combining the different multi attribute health states.

Explicitly decomposed models, the general class of explicitly decomposed models constitutes the Multi Attribute Utility method.

In the context of health it means that rather than having to rate multi attribute health states, the judge can rate each attribute separately. Utility functions are assessed over each attribute. Thereafter, through some scaling procedure, these utilities are aggregated over attributes. A very well known example of the explicitly decomposed method is the index constructed by Torrance.
Description of scaling methods

Psychometric Scales
As mentioned earlier, psychometric scaling is a procedure of assigning numbers to a property of subjects in order to impart some real number characteristics to them. The simplest kind of scales are rating scales or ranking scales. Wherein the different responses are simply arranged in the order of increasing intensity and by that virtue these scales become ordinal scales. Some of the well-known unidimensional scales are Bogardus social distance scale\(^1\), Thurstone scales, Likert or “summative” scale\(^2\), Guttman or “cumulative” scalogram\(^3\):

Decision Analytic Scales
The scales rooted in decision analytic framework are designed to attach preference weights to health state values. The following kinds of scaling procedures exist in the literature:

The rating scale
(a) category scaling\(^4\)
(b) visual analogue scale\(^5\)

The standard gamble\(^6\) (The SG technique has been widely used for valuing health states via a transformation through VAS. It has been used in HUI-II, HUI-III and condition specific health state vignettes),

Time trade off\(^7\),

4) Magnitude estimation
(a) Person Trade Off\(^8\)
(b) Ratio scaling, Willingness to pay.

\(^1\) It is used to measure the willingness of people to participate in social relations. Originally it was used to measure racial prejudice. Items are arrayed in increasing closeness of relationship to the respondent. Clear differences of intensity suggest a structure among the items. A person objecting to one of the “further away” measures is likely to object to the “closer” relationship as well.

\(^2\) It is used to measure the intensity of a respondent’s feeling or attitude on a particular topic. Subjects are asked to indicate their response on statements expressing a point of view on an issue on scales ranging from strongly agree, agree, neither agree nor disagree, disagree strongly. Numbers are assigned to each answer and the respondent’s score is added up.

\(^3\) A series of statements on a topic arranged according to their level of intensity on a single continuum. It is based on the fact that some items may be more extreme indicators of the variable than others. So anyone who gives a strong indicator of some variable will also give the weaker indicator. Here cumulative scaling or scalogram is used to ensure that there is only one unique combination of responses for each scale score. Here it is assumed that if a respondent agrees with an item then he also agrees with all previous items. This is what is meant by cumulativeness here. A scalogram analysis allows the examination of this cumulativeness. A scalogram analysis essentially means construction of matrix that shows the responses of all the respondents on all the items. The matrix is so sorted that respondents are arrayed according to the degree of their intensity on the scale. So that the respondents who agree with more statements are listed on top and those who agree with less statements are listed at the bottom. For respondents with same number of agreements, statements are sorted from left to right from those that most agreed to to those that fewest agreed to. So basically we have an arrangement of both the items and the respondents according to the intensity on the scale. The scale score is obtained using scalogram analysis.

\(^4\) here a specified number of categories are used. The most preferred health state is placed in the first category and the least preferred health state is placed in the last category, and the intermediate states of health are placed in the category that seems most appropriate to the subject in order to reflect the strength of the subject’s preference, assuming equal change in preference between adjacent categories.

\(^5\) here a visual aid such as a thermometer with a scale from 0 to 100 on a felt background with foam sticks labeled with health states is used. The subject places the foam sticks on the scale and adjusts their location until he feels confident that they reflect his true feelings (Torrance et al. 1982 in Torrance JHE 1986).

\(^6\) The rating scale has been used in valuing health states in QWB, HUI-II and HUI-III.

\(^7\) This is the classical method of measuring cardinal preferences. It is based on the fundamental axioms of utility theory, first presented by von Neumann and Morgenstern (1953 in Torrance JHE 1986).

\(^8\) The time trade off method was developed specifically for use in health care by Torrance et al. (1972) as an alternative to SG approach to get over the problem of explaining probabilities to respondents.
Multi Attribute Utility Health Indices

When the health states are described by a multi attribute classification system, and the scaling procedures rooted in decision theory are used to measure single health states then multi attribute utility theory can be used to combine together the values for these individual health states to obtain composite values for each health state description. The generic nomenclature for the health state indices obtained through the use of multi attribute utility theory is Quality of Life Indices. These QoL indices can be used for economic evaluation of health care programs as they represent the preference values attached with these indices.

Utility theory foundation of health states

According to Torrance, utility theory is a tool for quantifying and analyzing the way in which people make choices. Since it can deal with any quantifiable good, it has a natural use in health status index models (Torrance 1976). The application of utility theory foundation can provide a scientific basis to health status index models. It can help to establish weights for health states, settle the issue on whether to discount future health improvements and tell how to aggregate individual health improvements across the population. Dowei suggested that health and life cannot be valued directly. The demand for either should be regarded as demand derived immediately from "time" and ultimately from all things involving time as an input. When we seek an extension of life we are literally trying to buy time. So the problem now becomes of valuing an extra unit of time and Dowie suggests that this should be valued in terms of marginal utility of unavailable time.) Torrance has shown that it is reasonable to extend the six fundamental axioms of expected utility as propounded by Luce and Raiffa to the case of health states. Though this is done in terms of health as derived demand for time. This view of demand for health also enables to suggest the possible shape of the utility function for health whose basic unit of measurement is taken to be healthy days or health status unit days.

Multi Attribute Utility Theory

MAU theory takes us one step forward from the above application of utility axioms to value health. It helps to deal with the problem of maximizing utility when the decision maker is faced not with one single well-defined objective that has to be optimized but

* This is a technique of estimating social values of different health states Nord (1992) & Berg (1973)
several competing objective that have to be optimized. In the context of health, if the health states are described by a multi attribute classification system then the theory of MAU functions makes it possible that rather than having to rate each combination of the multi attribute health state individually, the judges can rate each attribute separately and then combine them suitably by using conditions for their combination as provided by the MAU theory. The MAU theory provides a mathematical model of the subject’s (the individual whose health state preferences are being measured) utility structure; which is used to determine the utility values for all possible health states in the classification system.

MAU theory is concerned with the construction of multi attribute utility functions (which may be additive, quasi additive, multiplicative and multi linear) and the independence conditions under which each would be appropriate. The combination of these individual utility functions is carried out via the following three tasks:

1. checking independence (among attributes) assumptions to determine which combination model linear, multiplicative or multilinear is appropriate.
2. Assessing utility functions over single outcome attributes.
3. Measuring the utility of selected multiattribute health states to determine scaling constants, thereby permitting aggregation of utility over attributes.

MAU health state values are used both for economic evaluation and clinical trial of health care programs. Several MAUs exist in the literature and they differ considerably in terms of their dimensions, item selection and preference weights. There is little guidance in the literature on which to use. Five commonly used MAUs are: the QWB, Rosser’s distress/disability classification, the HUI (marks I, II, III), EQ-5D and 15D.
PART – II

Purpose of present study

We propose to analyse the prevalence of morbidity, its severity and the distribution of health status across individuals with diverse socio economic characteristics and the distribution health or morbidity in the population. We propose to carry out this analysis from the information contained in the NSS survey on morbidity for the year 1995-96.

A multiattribute functional approach to construction of health status index using NSS data

The beauty of NSS data lies in the extent and depth of coverage of information it contains on the aspects of morbidity and the socio demographic profile of each individual in the family. The manner in which ailment has been defined and information on its intensity has been gathered, can be interpreted as the functional approach to measuring health.

Definition of functional health

How far is the individual able to carry on his typical daily activities is the functional view of health. In this view someone is healthy if he is physically and mentally able to do things he wishes and needs to do. The phrase “activities of daily living” epitomizes this approach (McDowell & Newell). Katz has pointed out that functional level may be used as a marker of the existence, severity and impact of disease even though knowledge about its etiology and pathogenesis is not advanced enough to permit measurement in these terms (McDowell & Newell 1996). Measuring functional level offers a convenient way to compare the impact of different types of disease on different populations at different times. It is in this spirit that one can look at NSS data and the concept of ailment defined therein.

Methodology

The National Sample Survey on morbidity gives information about the prevalence of ailments. Respondents were asked whether they have been suffering from any ailment during the reference period. The questions were asked in a dichotomous format, with only
two permissible categories of answers - yes or no. Such a measure of health is not very sensitive to variations in health status across individuals since it distinguishes only between two states – ill or not ill.

In order to be able to do so, we first need to set out the meaning of health. The meaning of health that is implicit in the NSS data is in sync with the abovementioned multiattribute functional conceptualization of health. This definition of health-illness status is made with reference to two criteria. First, it should be in terms of departures from normal role functioning. Second, the dysfunction should have some relevance to health in a physical or medical sense.

The number of possible attributes of health is limitless. The descriptors of dysfunctional status that have been selected by NSS include aspects of deviations from physical and mental well being. The way in which data has been gathered by the survey also generates information about health related aspects of social well being (although in a limited sense) i.e. was the person able to perform his social role. So information has been collected on ailment. Ailment is taken to include illness or injury and has been defined as any deviation from the state of physical and mental well being. In other words, one will be treated as sick if one feels sick. This means that the information on ailment that has been collected is a self reported one. Ailments have been taken to also include cases of visual, hearing, speech, and locomotor disabilities. Injuries covers all types of damages, such as cuts, wounds, hemorrhage, fractures and burns caused by an accident, including bites to any part of the body. An ailing member is a normal member of the household who was suffering from any ailment during the reference period. Cases of sterilization, insertion of IUD, getting MTP etc., pregnancy and child birth will not be treated as cases of ailment. But abortion, natural or accidental, will be treated as ailment. A case of ailment will generally be identified with a specific cause and attempt has to be made to treat ailment from two different causes as two cases of ailment even when the person is the same.

The information on ailment has been collected in a way that is indicative of the intensity of ailment. This in turn generates information about some aspects of economic, functional and social well being of a person. Questions were asked from the respondents about the number of days during the reference period when their activity was restricted or they were confined to bed owing to their ailment.
Where, disability of restricted activity means the state of health, which prevents the ailing person from doing any of his/her normal avocation. For economically employed persons, restricted activity will mean abstention from the economic activity. In case of a housewife, this will mean cutting down of the day's chores. In case of retired persons, this will refer to the pruning of his/her normal activity. In case of students attending educational institution, this will refer to abstention from attending classes. For infants below school going age and for the very old, restricted activity is not to be considered in view of the fact that their usual activities are of restricted nature.

Confinement to bed refers to a state of health where the ailing person is required or compelled to mostly stay in bed at his/her residence/home.

Number of days confined to bed within the reference period also includes days, if any of hospitalization. One will be considered hospitalized if one has availed of medical services as an indoor patient in any hospital. Hospital here refers to any medical institution having provision for admission of sick persons as indoor patients (inpatients) for treatment. Hospital covers public hospitals, community health centres and primary health centres (if provided with beds), private hospitals, nursing homes etc.

So we have information on the following aspects of health:
1. Physical well being and Mental well being.
2. Social activity.
3. Mobility.

Information on duration of deviation from the normal state on the above dimensions of health has been collected hierarchically. So that if a person had limited mobility for 1 day then he also had restricted social activity also for at least 1 day (it could be greater than 1 day but not less) and he was physically / mentally unwell also for at least 1 day (it could be greater than 1 day but not less). Similarly, if a person had restricted social activity also for 1 day then he would also be physically / mentally unwell also for at least 1 day (it could be greater than 1 day but not less).

On the basis of above information we can have functional level classification of the population. Because of the hierarchical ordering of the nature of dysfunction on the
abovementioned attributes of health we can create cardinal labels for population health in
the tradition of ranking scales. We propose to measure health on a scale of 0 to 1. Where
1 represents worst health and 0 represents good health (or not ailing), and call it Self
Reported Illness Index (SRII). This is a functional measure of health 9.

**Self reported illness index (SRII)**

We derive a measure of individual health from the information contained in the NSS data.
We call it the self-reported illness index (SRII). It is a generic non-preference based index
that measures of health that is increasing in the value of ill health. The greater the value of
the index the higher is the degree of ill health of an individual.

Typically, a decomposed method of construction of a multi attribute health status index
involves short-listing some chosen attributes of health 10 and combining them together
through the use of a suitably chosen multi attribute utility function. Alternatively, some
health status instruments ask the respondents to rate their health on several domains and
then an aggregate global measure of health status is obtained through a suitable scaling 11
technique. Both these methods while providing a continuous interval measure of health
suffer from too much subjectivity. The former scheme of things is subjective with respect
to the choice of a multiattribute utility function and the latter to the choice of the scaling
procedure. More importantly, we are unable to use these methods because no such
information has been collected in the NSS survey. So we adopt an objective approach for
the construction of illness index 12 using the information available in the NSS survey.

**Construction Of SRII**

Let us assume that the morbidity status of an individual can be characterized by a
continuum of values rather than by a simple dichotomous categorization of the health
status as ill or not ill. We can use a real number to represent this continuum of health

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9 In the literature,(Kaplan) there exist discussions about states of health which are considered to be worse than death and fit to be
coded as having a value less than zero. But we have no way of collecting such information and hence will restrict our measure of
health from 0 to 1.

10 Attributes of health have to be selected because health is multidimensional.

11 Scaling helps to determine a functional relationship between the observed response and the underlying unobserved perception. There
are several psychometric and decision theoretic scales to choose from for constructing the health status indicator (Torrance, 1986 &
Froberg & Kane, 1989).

12 We call it illness index because (a) it is constructed by combining attributes of illness as defined by NSS and (b) the higher values of
the index represent greater severity of illness.
status of an individual. While health (or ill) health by itself is a latent variable, we can observe several characteristics of health that may be used to assess the existence and extent of ailment in an individual and use these observed characteristics to quantify a level of health status (or its converse i.e. ill health or morbidity) for that individual.

So what we have is a Self rated illness index $Z$, which is a qualitative variable, that takes a finite number of ordered categorical values $c_1, c_2, ... c_m$. An individual is placed on any one these categories depending upon the values exhibited by him on the observed objective indicators of health. This is a rank ordering methodology, to construct a diversified health status of the individuals as opposed to a binary classification of the health status of individuals, without invoking the use of a multi attribute utility function or a scaling technique. Using these observed characteristics of health, we derive a global ordinal index of illness that ranks different states of ill health.

The observed objective indicators that have been taken as being reflective of the underlying unobserved true health is the absence or presence of days within the reference period for which the respondent is reported to be suffering from ailment with varying degrees of intensity.

The National Sample Survey on morbidity gives information about the prevalence of ailments. Respondents were asked whether they have been suffering from any ailment during the reference period. The questions were asked in a dichotomous format, with only two permissible categories of answers - yes or no. The information on ailment has been collected in a way that is indicative of the intensity of ailment.

Questions were asked from the respondents about the number of days during the reference period when they were ill, when their activity was restricted or when they were confined to bed owing to their ailment.

Ailment is taken to include illness or injury and has been defined as any deviation from the state of physical and mental well being\(^\text{13}\). In other words, one will be treated as sick if

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one feels sick. This means that the information on ailment that has been collected is a self reported one.

Where, the state of restricted activity means the state of health, which prevents the ailing person from doing any of his/her normal vocation. For economically employed persons, restricted activity will mean abstention from the economic activity. In case of a housewife, this will mean cutting down of the day’s chores. In case of retired persons, this will refer to the pruning of his/her normal activity. In case of students attending educational institution, this will refer to abstention from attending classes. For infants below school going age and for the very old, restricted activity is not to be considered in view of the fact that their usual activities are of restricted nature.

Confinement to bed refers to a state of health where the ailing person is required or compelled to mostly stay in bed at his/her residence/home. Number of days confined to bed within the reference period also includes days, if any of hospitalization. One will be considered hospitalized if one has availed of medical services as an indoor patient in any hospital. Hospital here refers to any medical institution having provision for admission of sick persons as indoor patients (inpatients) for treatment. Hospital covers public hospitals, community health centers and primary health centers (if provided with beds), private hospitals, nursing homes etc.

The “number of days” reported here do not correspond to health care utilization, but the number of days for which the respondent is ailing with varying degree of intensity irrespective of seeking health care. But while being self reported, this data is also more objective (in comparison to self rated health) in the sense that it simply does not record what the respondent is feeling but how he is feeling vis-à-vis his capability to carry out his functional responsibilities. The data on the number of days used for construction of this index is self reported data. Exploiting this information on the number of days spent in various health states, we construct an ordinal index of illness having four categories.

sterilisation, insertion of IUD, getting MTP etc., pregnancy and child birth will not be treated as cases of ailment. But abortion, natural or accidental, will be treated as ailment.

The use of number of days spent in a given health state is used elsewhere also. The centre for disease control (CDC), USA also has a number of healthy days as an indicator of health.
Z=1 represents person is not ailing.
Z=2 represents person is ailing without activity restricted days
Z=3 represents person is ailing with some days within the 2-week reference period with activity restricted
Z=4 represents person is ailing with some days within the 2-week reference period with confinement to bed.

So what we have now is a multiple category self reported illness indicator. Where, 1 represents full health and 4 represents worst health but not death. The manner in which the NSS defines activity restricted and confinement to bed, reflects health as the functional ability of a person on a multidimensional domain of health. The information provided covers the following aspects of health: Physical well being and mental well being, social activity and mobility

This theoretical construct compares well with the notion of health that is used in some of the well-known health indices like RAND SF-36 health index, Quality of Well Being Index etc.

Internal consistency

We performed Cronbach alpha test to check the internal consistency of the items that have been selected for constructing the health status measure and found its value to be as high as 98%.

Typically, in India, the level of morbidity is measured by taking the number of people who are ill as a percentage of total population. This is how the extent of morbidity is computed from the NSS reports on morbidity also. However, this percentage of people reporting ill is compatible with very different scenarios about the nature and intensity of ailment. So we need to attach different weights to people suffering from different intensity of morbidity. To take into account the heterogeneity in the health states of the individuals, we derive a methodology in the special context of the NSS data.
The measure of morbidity that is obtained as SRII, does not permit the quantification of inequality in health. The conventional measures of inequality require that the variable whose inequality is to be computed should be a continuous variable. In the literature on health inequalities, primarily three techniques have been used to convert the multiple category discrete indicator of health, such as the Self Assessed Health Status, into a continuous variable. These are (1) a non regression based method (Wagstaff & Doorslaer 1994), (2) OPROBIT Regression method (Cutler & Richardson 1997, Groot 2000) and (3) Interval Regression (Doorslaer & Jones 2003).

All the three methods are upon the concept of health being a latent variable. The true health $H^*$ of an individual is a latent variable that cannot be observed directly. What is observed is a subjective measure of health status $H^5$, which is categorical in nature like the Self Rated Health (SRHS) or SRII. The notion of $H^5$ corresponds to the idea that the whole continuum of true health is which is unobserved can be categorized into a finite number of categories and the individuals while reporting their health status, place themselves in one category or the other depending on their true health. The process of converting the categorical health status $H^5$ into a continuous health status involves finding the threshold values of the true latent health $H^*$ which correspond to the different categories of $H^5$.

Suppose, $H^5$ has J categories, with category 1 corresponding to best health and category J corresponding to worst health than $H^*$ and $H^5$ are related as follows:

$H^5 = 1 \text{ if } -\infty < H^* \leq \alpha_1$

$H^5 = 2 \text{ if } \alpha_1 < H^* \leq \alpha_2$

$H^5 = 3 \text{ if } \alpha_2 < H^* \leq \alpha_3$

$\vdots$

$H^5 = J \text{ if } \alpha_{J-1} < H^* \leq +\infty$

Where $\alpha_i$ are the thresholds.
Non Regression Based Method for converting qualitative health into quantitative health

The Non regression based method suggested by Wagstaff & Doorslaer (1994) assumes the latent health to be following a standard normal distribution. The values of $H^*$ for each individual are computed as follows. The J-1 thresholds are computed as

$$\alpha_j = \phi^{-1} \left( \sum_{i=1}^{j} n_i / N \right), j = 1, 2, \ldots , J-1.$$  

Where, $\phi^{-1}$ is the inverse of standard normal cumulative density function, $n_j$ is the number of cases in category $j$ and $N$ is the total number of cases. After estimating the thresholds, the mean value of $H^*$ is in each of the intervals $\alpha_{j-1} < H^* \leq \alpha_j$ is estimated as normal score using the formula

$$\text{Mean } H^* = \left( \frac{N}{n_j} \right) \left[ \phi(\alpha_{j-1}) - \phi(\alpha_j) \right]$$

The limitation of the above method is that it assumes the underlying latent health to follow a standard normal or lognormal distribution. This is a very stringent assumption. Another limitation of this approach is that it does not permit functional flexibility in modelling the factors that influence health.

The OPROBIT Method for converting qualitative health into quantitative health

An individual's health status can be said to be related to his individual and socio economic characteristics like his age, education, income, place of residence, marital status, genetic endowments, gender etc. For $i^{th}$ individual, if $h^*_i$ is his health and $x_i$ is the variable that influence his health

$$h^*_i = \beta x_i + e_i$$  \hspace{1cm} (1)

But $h^*_i$ is not measured on a cardinal scale. It is measured as an ordered categorical variable. So this equation is estimated by an OPROBIT regression. The specification of OPROBIT is as follows-

The latent health variable is assumed to be related to the objective health measure and to some other individual characteristics in the following way:

We have true health $h^*$ which is a latent variable, but what we observe is categorical health $h^s_i$, then,

$$h^s_i = j \text{ if } \mu_{j-1} < h^* < \mu_j \text{ for } j = 1, \ldots , n$$  \hspace{1cm} (2)
This latent health can be decomposed into observable and unobservable components. The observable component is based on the vector $x_i$, while the unobserved component $\varepsilon_i$ is considered to be random.

$$h_i^* = \beta x_i + \varepsilon_i \quad \varepsilon_i \sim N(0,1)$$ (3)

Estimates of $\beta$ and $\mu$ are obtained by Maximum likelihood estimation. The linear predicted value of $h_i^*$ can be considered as a measure of health status. Jones & Doorslaer (2003) say that when these predicted values are rescaled to the [0,1] interval, they can be used as a utility proxy. If $y^1$ is the predicted linear index from OPROBIT, then $y^2$ the [0,1] interval rescaled variable is computed as

$$y^2 = (y^1 - y_{\text{min}})/(y_{\text{max}} - y_{\text{min}})$$

where, $y_{\text{max}}$ is the largest predicted value of $y$ and, $y_{\text{min}}$ is the smallest predicted value of $y$.

The Interval Regression Method for converting qualitative health into quantitative health

This method is a variant of the OPROBIT method which is used when information on values of upper and lower limits of the interval are known from some other measure of health like HUI (Doorslaer & Jones 2003). This approach is valid if there is a direct mapping of categorical health such SRHS or SRII to the other measure of health.

Estimation of Quantitative Health Status from OPROBIT Regression

In our case we cannot use the Interval Regression method because information on another measure of health is not known to us. Ordered probit method is superior to the Non-regression based method. So we use the OPROBIT regression method to compute the continuous measure of health.

We regress SRII on those variables, which may be thought to influence the true latent health of an individual. These variables will relate to the personal characteristics of an individual, his socio economic conditions and his objective health conditions. In our estimation we capture the personal characteristics of an individual by his age and gender. We use the per capita final consumption expenditure of the individual to represent his
socio economic conditions, and the nature of the diseases to indicate his objective health conditions.

The variables used are as follows:

**Dependent Variable SRII**

**Independent Variables:**

- **age**: age of the individual
- **pce**: per capita final consumption expenditure
- **male**: a dummy variable for gender
  - male = 1, if an individual is male, 0 otherwise
- **acute**: a dummy to show whether an individual is suffering from acute disease or chronic disease
  - acute = 1, if disease is acute, 0 otherwise
- **infectus**: a dummy to show if an individual is suffering from infectious disease
  - infectus = 1, if disease is infectious, 0 otherwise
- **fever**: a dummy to show if an individual is suffering from short duration fever
  - fever = 1, if an individual has fever, 0 otherwise
- **lifestyl**: a dummy to show if an individual is suffering from lifestyle disease
  - lifestyl = 1 if an individual is suffering from lifestyle disease, 0 otherwise
- **age_dis**: a dummy to show if an individual is suffering from age related disease
  - age_dis = 1 if an individual is suffering from age related disease, 0 otherwise
- **unhygnic**: a dummy to show if an individual is suffering from disease caused due to lack of hygiene
  - unhygnic = 1 if an individual is suffering from disease caused due to lack of hygiene, 0 otherwise

**_cut1, _cut2, _cut3** are the threshold values generated by the OPROBIT regression

The results are presented in Table A2.1.

**Validation of the health measure**

We perform a split sample cross validation to check how good our measure of health is. The data is split randomly so that we have one sub sample (50% data), which is used for development of the model and the other sub sample (the other 50% data), which is used for validation of the model.

We can use the method of split sample validation to check the construct and concurrent validity of the health status measure that we have constructed. We split our data into two random sub samples and use the health status measure generated from one sub sample as a predictor of health care utilization on the other sub sample.

---

1 The time duration and intensity of illness depend on the nature of disease and this in turn is expected to affect an individual’s health status.
In the first sub sample, we use the OPROBIT regression method outlined above, to construct a continuous variable called morbidity from SRII. In the second sub sample, we ran a logit regression and used this variable called morbidity as a predictor of health care utilization. Then we compared the probability of seeking treatment (which is an indicator of health care utilization) as obtained from the logit regression, with the actual data which tells us whether an individual sought treatment (called Treated1)) or not. We compare the association between the predicted probability of treatment\(^2\), called, \(\text{Pr} (\text{treated1})\) with the actual variable as obtained from data, called Took (treat), by using a Two Way Contingency Table. We find a good association between the actual data variable and the predicted variable. So we infer that the continuous measure of health status constructed by us is a valid measure. The results of the logit regression are presented in Table A2.2. The Two way contingency table is presented in Table A2.3.

\(^2\)This is obtained as a prediction from the logit regression.
### Table A2.1
**OPROBIT Regression for Continuous Health Measure from SRII**

| Coef. | P>|z| |
|-------|----|
| Age   | 1.25E-02 | 0 |
| Pce   | 1.87E-06 | 0 |
| Male  | 0.01116  | 0.155 |
| Acute | 3.228642 | 0 |
| Infectus | 0.576341 | 0 |
| Fever | 0.70178  | 0 |
| Lifestyl | 3.105851 | 0 |
| age_dis | 3.160892 | 0 |
| Unhygnic | 2.325313 | 0 |
| cut1  | 2.792437 | |
| cut2  | 3.846086 | |
| cut3  | 4.297562 | |

### Table A2.2
**Logit Regression for Cross Validation**

| Coef. | Std. Err. | z    | P>|z| |
|-------|-----------|------|----|
| morbidity | 2.124106 | 0.010783 | 197 | 0 |
| pce   | 2.34E-06 | 3.56E-07 | 6.57 | 0 |
| age   | 0.000516 | 0.000677 | 0.76 | 0.446 |
| urban | 0.343294 | 0.030574 | 11.23 | 0 |
| male | 0.031098 | 0.028966 | 1.07 | 0.283 |
| cons  | -5.18228 | 0.035522 | -145.89 | 0 |

### Table A2.3
**Contingency Table**

<table>
<thead>
<tr>
<th>TREATED</th>
<th>Pr(treated 1)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>297721</td>
<td>2171</td>
</tr>
<tr>
<td>% within TREATED 1</td>
<td>99.3%</td>
<td>.7%</td>
</tr>
<tr>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>2285</td>
<td>12766</td>
</tr>
<tr>
<td>% within TREATED 1</td>
<td>15.2%</td>
<td>84.8%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>300006</td>
<td>14937</td>
</tr>
<tr>
<td>% within TREATED 1</td>
<td>95.3%</td>
<td>4.7%</td>
</tr>
</tbody>
</table>

0-represents people who did not seek treatment
1-represents people who sought treatment

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APPENDIX – 3

DEFINITION OF THE VARIABLES USED IN
THE REGRESSION & DECOMPOSITION ANALYSIS
AS SHOWN IN TABLES 4.1 TO 4.17

<table>
<thead>
<tr>
<th>Variables used in the regression for decomposition of inequality in morbidity</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>age</td>
<td>age of the individual</td>
</tr>
<tr>
<td>gender</td>
<td>male-dummy variable to represent the gender</td>
</tr>
<tr>
<td>male</td>
<td>1 and female</td>
</tr>
<tr>
<td>hhsize</td>
<td>hhsize-size of the household of the individual</td>
</tr>
<tr>
<td>urban</td>
<td>urban-dummy variable to represent the place of residence</td>
</tr>
<tr>
<td>urban</td>
<td>1 and rural</td>
</tr>
<tr>
<td>kutch</td>
<td>kutch - dummy variable to show structure of the dwelling, whether kutcha or pucca</td>
</tr>
<tr>
<td>kutcha or semi pucca</td>
<td>1 pucca</td>
</tr>
<tr>
<td>unedu</td>
<td>unedu-dummy variable to show education level of the individual, illiterate or people educated</td>
</tr>
<tr>
<td>below primary are coded as uneducated, unedu</td>
<td>1</td>
</tr>
<tr>
<td>maried</td>
<td>reference category is educated people who have received education above primary level coded as educated, edu</td>
</tr>
<tr>
<td>employed</td>
<td>employed-dummy variable to show if an individual is employed</td>
</tr>
<tr>
<td>not_work</td>
<td>not_work-dummy variable to show if an individual is either engaged in domestic work or a student</td>
</tr>
<tr>
<td>nev_mard</td>
<td>nev_mard-dummy variable to show marital status of the respondent,</td>
</tr>
<tr>
<td>never married includes people who are not currently married</td>
<td></td>
</tr>
<tr>
<td>maried</td>
<td>people who are currently married</td>
</tr>
<tr>
<td>smokes</td>
<td>dummy variable to show if an individual smokes</td>
</tr>
<tr>
<td>use_toba</td>
<td>dummy variable to show if an individual uses tobacco</td>
</tr>
<tr>
<td>no_lat</td>
<td>dummy variable to show if an individual has access to toilet facilities no_lat</td>
</tr>
<tr>
<td>shows no toilet</td>
<td></td>
</tr>
<tr>
<td>no_drain</td>
<td>dummy variable to show if an individual has access to drainage facilities no_drain</td>
</tr>
<tr>
<td>shows no drainage or open drains</td>
<td></td>
</tr>
<tr>
<td>cov_drain</td>
<td>reference category is people who have access to covered drains</td>
</tr>
<tr>
<td>spray</td>
<td>dummy to show if the area around the individual's house has been sprayed with insecticides</td>
</tr>
<tr>
<td>drink_wat</td>
<td>dummy variable to show whether an individual has access to safe drinking water</td>
</tr>
<tr>
<td>ndrink_w</td>
<td>people who do not have access to safe drinking water</td>
</tr>
<tr>
<td>inf_nwat</td>
<td>presence of infectious disease multiplied with non availability of safe drinking water</td>
</tr>
<tr>
<td>inf_nlat</td>
<td>presence of infectious disease multiplied with the non availability of latrine</td>
</tr>
<tr>
<td>inf_ndra</td>
<td>presence of infectious disease multiplied with the non availability of drainage</td>
</tr>
<tr>
<td>Variable</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>fev_nwat</td>
<td>presence of fever multiplied with the non availability of safe drinking water</td>
</tr>
<tr>
<td>fev_nlat</td>
<td>presence of fever multiplied with the non availability of latrine</td>
</tr>
<tr>
<td>fev_ndra</td>
<td>presence of fever multiplied with the non availability of drainage</td>
</tr>
<tr>
<td>fev_nspr</td>
<td>presence of fever multiplied with the non spraying of insecticide</td>
</tr>
<tr>
<td>hyg_nwat</td>
<td>presence of diseases caused by lack of hygiene multiplied with non availability of safe drinking water</td>
</tr>
<tr>
<td>hyg_nlat</td>
<td>presence of diseases caused by lack of hygiene multiplied with the non availability of latrine</td>
</tr>
<tr>
<td>hyg_ndra</td>
<td>presence of diseases caused by lack of hygiene multiplied with the non availability of drainage</td>
</tr>
<tr>
<td>med_ex_1</td>
<td>total medical expenditure undertaken for treatment of disease</td>
</tr>
<tr>
<td>govprox</td>
<td>whether a government medical facility is available in close proximity of the individual</td>
</tr>
<tr>
<td>medfac</td>
<td>whether any medical facility whether government or private is available in close proximity of the individual</td>
</tr>
<tr>
<td>cons</td>
<td>constant</td>
</tr>
</tbody>
</table>

In the Tables 4.1 to 4.17

The column titled Mean gives the mean value of each of the variables.
The column titled Coef. gives the value of the regression coefficient.
The column titled P>(t) shows the significance of the regression coefficient.
The column titled Contrb. To Gini gives the percentage contribution of each of the regressors to Ystar.
It sums to 100%.
G(Y) - Gini coefficient of morbidity
G(yhat) - Gini coefficient of estimated morbidity
G(ystar) - Gini coefficient of the deterministic portion of estimated morbidity
CO(e) - gives the contribution of the residual term to inequality in morbidity
CO(constant) - gives the contribution of the constant term to inequality in morbidity
CO(Ystar) - gives the contribution of the deterministic portion to inequality in morbidity
The three contributions add up to 100%.