Distribution of Disease Burden and Epidemiological Transition

In the Indian States: 1995 -2014

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ABSTRACT

The study carries out epidemiological transition analysis of disease burden from 1995 to 2014 in India and States for selected diseases. Disability Adjusted Life Years (DALY) methodology has been adapted for disease burden estimation using Medical Certification of Cause of Death (MCCD) and Sample Registration Survey data. The study further elaborates on the essence of decomposition into age structure, death rate and age at death in order to better analyze health system progression. Results indicate wide diversity among states in bearing the burden of communicable, non-communicable and injury. Some states like Bihar, Chhattisgarh and Madhya Pradesh are facing the dual burden of diseases. Findings of the study would be useful in tailoring health care expenditures at regional level based on population health needs thus improving technical and allocative efficiency of health systems.

Keywords: Age structure, DALY, India, Health, disease burden

BACKGROUND

In past decade, evaluation of macro- and microeconomic impact of disease/injury has become an integral part of global growth assessment. The concern is greater for developing nations like India that faces the dual burden of diseases and stands to lose $4.58 trillion (2015-2030) due to non-communicable diseases alone (World Economic Forum, 2014). On the other hand, communicable diseases like tuberculosis and diarrheal still rank among topmost causes of premature death. Even with continued growth in per capita health expenditure, from $60 to $267 during 1995-2014 (constant 2011 PPP) India still ranks 154 among 195 countries as per global burden of disease study(GBD) (Vos et al.,2015). This is a strong indicator that increased expenditure alone cannot provide better health outcomes and more decision parameters are called for informed spending.

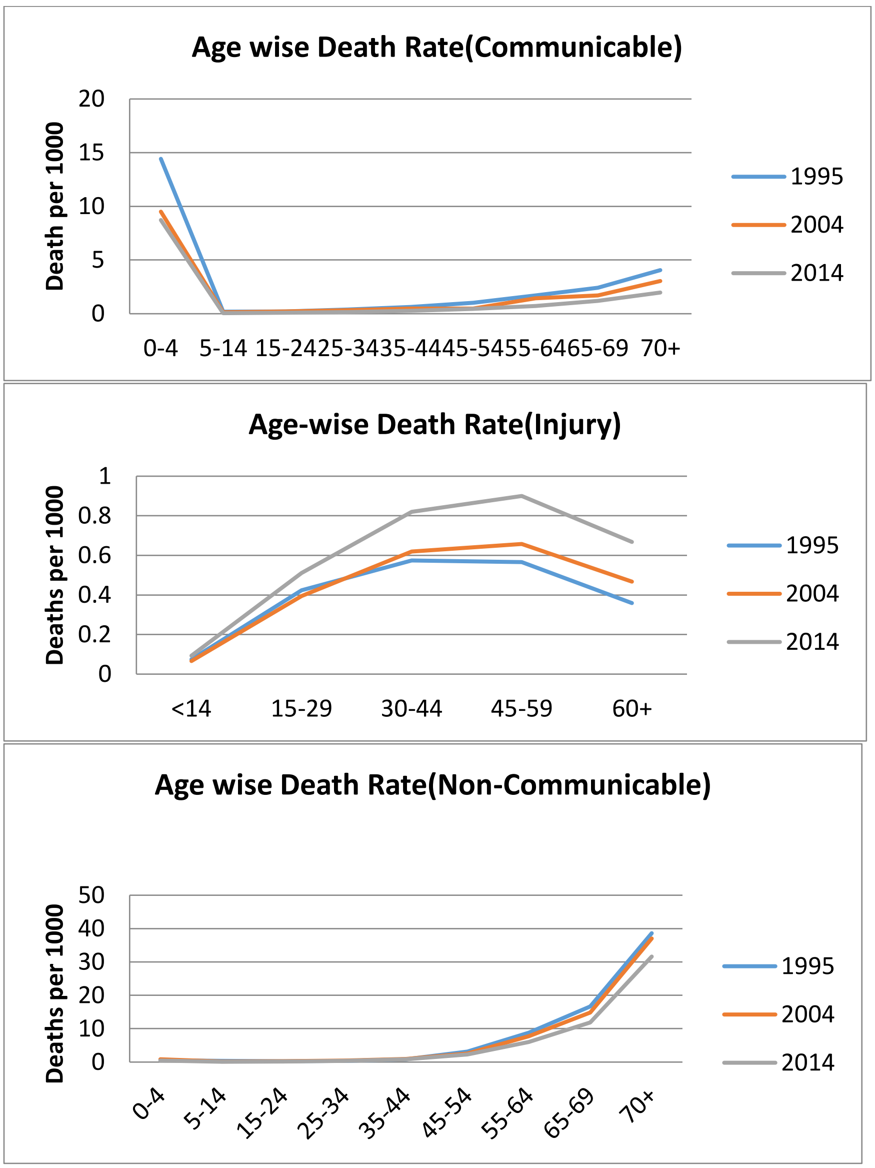

Figure 1 Age-wise Death rate for 1995, 2004, 2014: a) Communicable b) Non-Communicable c) Injury

Efforts to improve the condition of health system have significantly scaled up in recent decade with greater autonomy provided to states in terms of fund allocation. But in the absence of reliable local health summary measures, this has resulted in the inefficient allocation and unutilized funds

(Paxton et al., 2014). Recent national health reports are emphasizing on the need for development of sub-national disease burden estimates for better informed fund allocation yet such reports still rely on mortality rates or case detection rate without switching to the advanced methods used by global disease burden studies by World Health Organization (WHO) (National Commission on macroeconomics and health 2005, Annual Report of Department of Health and Family Welfare 2016-17). The mortality rate varies significantly across ages and disease category (Figure 1) and to account for this variation, more evolved summary measures took shape in the mid and late 1900s. Disability Adjusted Life Years (DALY), used in GBD study, is one such measure that captures mortality and morbidity in a single number and represents it in life loss.

Our study is the first attempt in sync with global burden of diseases, Injuries and Risk Factors (GBD) enterprise to estimate disease burden transition of selected diseases in the Indian States from 1995 to 2014. We extend the study and decompose the transition of burden into contributions by changes in Age structure, death rate and age at death. Demographic shift i.e. change in age structure plays a significant role in the transition of diseases and hence bears major implication for planning (Murray, 2012). As the society ages, the burden is expected to shift its course from communicable to non-communicable diseases (NCDs). Therefore, this component is expected to be positive for NCD and negative for communicable (and perinatal) diseases given decline in fertility rates in India. Death rate and age at death truly reflects the achievements of the health system and should assume negative values to reflect health system progression. The decomposed analysis serves as a better guide for assessment of health system progress which otherwise is misinterpreted. The study also takes on record keeping issues at state level and utility of national survey data for disease burden studies. Unfortunately, we did not come across any study in India that controls for age structure change and other two components while studying impact evaluation of health interventions.

Results reveal an overall decline in disease burden from 1995 to 2014 but significant increase in burden due to injuries in young adults. As anticipated, the disparity between states due to age structure variation is high indicating that regions within India are at the distinct stage of epidemiological transition.

LITERATURE REVIEW

The global healthcare industry is expected to reach $8.7 trillion by 2020. The increase can be attributed to many factors like cost of services, pharmaceutical productiveness, demographic shift, epidemiological transition and socioeconomic factors. With this progression, every economy, in general, is facing an upward pressure on health expenditure thus making resource allocation central to health systems planning. To reach allocative efficiency, policies driven solely by mortality rate are not enough as they are not comprehensive to account for morbidity, disease category, cost-effectiveness, health perception and decision making (Gold et al., 2002). The need for the comprehensive measure was felt to account for these limitations and hence population health summary measures like Quality-adjusted Life Years (QALY) and Disability Adjusted Life Years (DALY) took shape.

Population health summary measures are statistics that represent morbidity and mortality in a single number (Molla, 2001). QALY and DALY are such measures that represent disease burden in terms of years of life saved and loss respectively. QALY was devised during the late 1960s and is generally used in the cost-effective analysis of health intervention (Gold et al, 2002). It was originally derived from welfare economics and expected utility theory (Pliskin et al, 1980; Torrance, 1987).

DALY, the method used for this study, was a collaborative effort of World Health Organization (WHO) to quantify the burden of disease and injury and to be used as a directive for resource allocation (Murray, 1994; Murray et al, 1996). DALY is composed of two components: Years of life lost due to premature death (YLL) and Years of life lived with disability (YLD). YLL is a reflection of life lost between the age of death and life expectancy at the age while YLD represents life loss due to morbidity. Murray (1994) also proposed the inclusion of social weights in the disease burden estimates.

Social weighting in DALY implies weighing for age and discounting of future health benefits (Murray, 1994). The justification of age-weighting is grounded in two arguments. First, as per human capital theory where man is considered machine and expected to produce economic output. Therefore, accordingly, work year loss is considered economically more important (Haenszel, 1950). The second argument stands on varied social responsibilities that individuals take up at different ages and hence advocacy for different weights is justified (Daniels, 1985). Anand & Hanson (1998) argues against age weighing in DALY as it rejects human capital framework altogether. If the economic value is to be considered, then discounted lifetime earnings should also be part of age weighting. And if social roles form the basis for age weighing then profession of the individual becomes an important parameter to be included, which is not the case. Later, Barendregt et al. (1996) brought to notice the issue in the methodology of age weighing in DALY by Murray (1994) which is, in actual, giving higher weight to age 0-27 rather than working age of 9-54. Given such methodological and social arguments against age weighting, it has been reconsidered for refinements and is dropped from WHO periodic release of global disease burden study.

The argument of time discounting originates from the simple economic concept of time preference i.e. expenditure in health to receive benefits today should be preferred over expenditure in future. The discounted DALY implies a present value of the infinite stream of DALY. Discounting is an unresolved debate with various for and against views like there is no reason to value well-being today more than in future especially when utility will be higher in future in face of consumption growth. If DALY is not discounted then it may entail cent percent of resources to be employed in an infinite stream of DALY elimination (Murray, 1994). Non-discounting may also result in overestimation of the cost-effectiveness of interventions (Martens and Van Doorslaer, 1990). Another matter of debate is whether the rate of discount for health benefits should be equal or lower than monetary items (Parsonage and Neuburger, 1992). Study on disease control priorities in developing countries by World Bank suggests the low discount rate of 3 percent (Alleyne et al., 2006) which is now a consensus. The calculation of DALY has been detailed in the methodology section. In our study, we have calculated DALY with and without weights to explore the sensitivity of results.

With access to reliable data and these summary measures, every country is advancing towards empirically driven resource allocation with higher confidence. A lot many countries have started generating disease burden estimates with improved accuracy at national and sub-national level (Lozano et al, 1995; Würthwein et al, 2001; Murray, 2000; Ljung et al, 2005; Rehm et al, 2006;

Öberg et al, 2011; Krishnamoorthy et al, 2009; Gómez-Dantés et al, 2016; Nomura et al, 2017). Yet efforts in the development of such measures in low-middle income countries are still at the elementary stage and are less comprehensive. In India, few studies have looked at disease burden from loss of life perspective (see Krishnamoorthy et al, 2009; Murthy et al 2010). National level estimates for India are available only through global disease burden study by WHO for the year 1990, 2004 and 2013 and by the Institute for Health Metrics and Evaluation (IHME) for the year 2010 and 2015. As per IHME report (2010), between 1990 and 2010 India reports a decline of total disease burden from 63.8 to 45.8 DALY per thousand yet diarrhea and perinatal conditions continues to be the topmost cause of mortality. During this period, non-communicable diseases also moved up the ranking which emphasizes the need to study regional disparities in India for better-targeted interventions.

In India, government reports like National commission on macroeconomics and health (NCMH) 2005 and National Health Policy 2015 still relies on mortality rates and only touch base upon disease burden by quoting national level figures computed by global burden of disease studies. However, such reports do recognize the need for sub-national health planning to achieve Millennium Development Goals (MDG) goals where India is lagging by almost a decade (National commission on macroeconomics and health 2005; Nath 2011; Ministry of Statistics and Programme Implementation 2015).

NCMH report also takes on the concept of vertical v/s horizontal programs which distorts the resource and fund allocation. Vertical programs are the one designed centrally which often ignores the priority and needs at state level thus weakening the 'locally designed' horizontal programs. In a developing country setting, where resources are limited, the debate of choosing one over the other requires comparative effectiveness and cost-benefit analysis. This is feasible only when morbidity and mortality of target diseases are expressed in the common form (Mills, 1983). In line with this requirement, NCMH attempted to determine baseline prevalence of individual diseases across India in 2005 but did not discuss disease burden in terms of life loss thus missing out on a comparative assessment of burden. Nevertheless, it highlights the rise of non-communicable diseases among poor sect as well which received no policy attention in the past. Such findings emphasize the need for periodic disease burden estimation across all regions.

Another report by Planning Commission (2011) on 'High-level expert group on Universal Health Coverage (UHC), India' recommends customization of UHC package at five levels viz 1) Village and community level 2) Sub-Health center level 3) Primary health Center 4) Community Health Center and 5) District Hospital. Such a suggestion is grounded on high variability in demand and services across and within states. It drives the attention towards the development of effective horizontal programs, better federal-state co-ordination and reliable local health summary measures. On similar lines, a study on allocative efficiency under National Rural Health Mission (NRHM), a signature program by Ministry of health India, finds that funds are being allocated on population count instead of health need (Paxton et al., 2014). Our study is in line with the recommendations by several reports that bring out the need for empirical decision making at sub-national level for cost-effectiveness and improved efficiency.

Countries like Mexico, Japan are among forerunners of comprehensive disease burden calculation exercise at the sub-national level. An epidemiological study in Mexico is cross-sectional in nature, designed with an aim to determine disparity among regions using DALY methodology (Stevens et al, 2008). Nomura et al (2017) extend their study further to analyze epidemiological transition between 1990 and 2015 in Japan. A global disease burden comparative study by Murray (2012) between 1990 and 2010 attempts to attribute the absolute change in burden to death rate and age structure.

Our study, in a first, carries out two decades epidemiological transition analysis between 1995-2004 and 2004-2014 in India and States. Fourteen diseases have been selected for the study containing a mix of communicable, non-communicable and injury in view of socio-economic representation and magnitude of burden. Further, the change in burden is decomposed into three components: 1) age structure, 2) Death rate, and 3) Age at death. First two components are in line with the study by Murray (2012). We consider attribution of change in burden due to ‘age at death’ (third component) is also a significant indicator of health system advancement. To our knowledge, this is the first study that attempts to analysis disease burden transition and its attribution to three different causes.

METHODOLOGY:

Study Design

The study aims to estimate and compare disease burden due to mortality and morbidity of selected diseases in India and States from 1995 to 2014. For mortality data, we have used Medical certification of cause of death (MCCD) reports and Sample Registration System (SRS). And for morbidity, disease prevalence and duration of illness are taken from regional studies and later checked for internal consistency using DisMod II tool. Fourteen diseases are selected as per GBD 2015 study based on the magnitude of their disease burden. First, we estimate disease burden of selected diseases for India and States for the year 1995, 2004 and 2014. Next, the change in disease burden between the years is decomposed into three components namely change due to age structure, death rate and age at death. Disease selected for the study constitutes a mix of communicable, non-communicable and injury which permits observation of trend differential among three categories across states.

Calculation of Disease Burden

Among various indicators of disease burden, Disability-adjusted life years (DALY) enables comparison of mortality and morbidity due to varied diseases based on time loss. It entails calculation of two components; years of life lost due to premature death (YLL) and years of life lost due to non-fatal health consequences or disability (YLD)(Murray,1994). DALY captures the age of disease onset or death as well thus allowing estimation of the value of time loss and policy impact at different ages (Devleesschauwer et al. 2014). We have adopted DALY methodology for disease burden calculation for India and states to study the change in trend over two decades.

Cause-age specific mortality rates are used for calculation of years of life lost for each disease as per formula (1). Here, India’s life expectancy in 2014 has been used for YLL calculation of all states in the year 2014, 2004 and 1995. For example death at age 5 implies life loss of 64.4 while a death at age 70 implies 8.1 years of life loss.

YLL= Number of deaths X Life expectancy at the age of death (1)

YLDs are the product of respective disease prevalence and corresponding disability weight. Calculation of YLD is done using DisMod II tool (Disease modeling tool) which utilizes mortality rate, prevalence rate and case fatality rate as input and provide consistent incidence rate, prevalence rate(and others) as output. Duration of illness for calculation of YLD (2) is taken from literature and latest disability weights (GBD 2010) have been applied for all years to suffice comparison. Disability weights, as per GBD 2010, signifies the empirical value of judgment of the general public regarding health severity (Murray, 2012).

YLD = Number of cases X duration till remission or death X disability weight (2)

Equation (3) gives general form of DALY at a time'tʼ for disease (or sequela) 'j' for a person 'i' (Murray & Acharya, 1997).

$$\Delta_{ij}^{t} = \int_{a_i^t}^{a_i^t + L(a_i)} K D_j C x e^{-\beta x} e^{-r(x - a_i^t)} dx \quad (3)$$

where 'x' is time, a_i^t is age of onset of disease, $L(a_i)$ is duration of illness and D_j is disability weight. Disability weight varies between 0-1, where 0 represents complete state of health and 1 represents death. Murray & Acharya (1997) also included provision for social weights for different age represented by β (with K as age modulation constant, takes value 0 or 1) and for discount rate 'r'. The concept of age-weights signifies unequal economic importance to different ages of life which provoked debate about its relevance and impact on result (see Barendregt et al 1996). For the purpose of this study, we have calculated results with and without social weights to examine sensitivity of results.

Decomposition

For decomposition, only YLL component of disease burden is considered since it is desirable for early mortality to decrease but the effect on morbidity is unclear. Morbidity is likely to increase or decrease depending on nature of disease hence not included in decomposition analysis. From disease burden estimates of 1995, 2004 and 2014, we calculate the difference between YLL (refers to YLL per 1000) of two years for each disease while controlling for age structure termed as 'absolute change' (δ_{Abs}) (4). It is desirable that 'δ_{Abs} shows a downward trend over the years. We argue that 'δ_{Abs}' alone is not a sufficient indicator of health system betterment. The change can be because of various deterministic factors and should be analyzed separately for informed decision making. In a comparative global burden study by Murray et al. (2012), decomposition of absolute change is analyzed in terms of aging, population growth, and death rates. We are, additionally, breaking it down into 'age at death' which is an essential indicator of health system impact on longevity.

$$\delta_{Abs} = YLL^{[t+1]}_{[t\ age\ weights]} - YLL^{[t]}_{[t\ age\ weights]} \quad (4)$$

$$\delta_{AS} = \delta_{Abs} - [\delta_{DR} + \delta_{DA}] \quad (5)$$

Thus, in our study absolute change is further decomposed into three different components: YLL change due to 1) Age structure (δ_{AS}); 2) Death rate (δ_{DR}); and 3) Age at death (δ_{DA}). Age structure (δ_{AS}) component is the difference between absolute change and sum of change due to death rate and age at death (5). The component is expected to assume a negative value for communicable & perinatal conditions while being positive for non-communicable diseases. In case of injuries, it is difficult to predict its course.

$$\delta_{DR} = YLL^{[\text{'t+1'}]}_{[\text{ t Death Rate}]} - YLL^{[\text{'t'}]}_{[\text{t Death Rate}]} \qquad (6)$$

Death rate (δ_{DR}), measured in years per 1000, is the proportion of YLL change due to variation in death rate across all age groups (6). It is desirable for δ_{DR} to decline for all diseases across all age groups to indicate population health improvement.

$$\delta_{DA} = YLL^{[\text{'t+1'}]}_{[\text{ t age weights, t+1 Death Rate}]} - YLL^{[\text{'t+1'}]}_{[\text{ t age weights, t Death Rate}]} \qquad (7)$$

Age at death (δ_{DA}) (in years per 1000) is YLL change due to variation in age at death between 't' and 't+1' (7). Without any argument, this component should assume a negative value which indicates deferral of death owing to access to quality care. The net effect of components can be misleading in indicating the actual effect of health intervention, therefore, disaggregation can bring out real progress made by different states towards building a healthy society.

DATA:

Cause of Death & Diseases

For the calculation of burden due to premature death (YLL), 'age at death' and 'life expectancy at the age of death' are required variables. Morbidity burden (YLD) is more complex to determine which requires incidence rate of disease, duration of illness and disability weight. Disability weights, as per GBD 2010, signifies the empirical value of judgment of the general public regarding health severity and takes value from 0 (state of complete health) to 1 (death). Incidence rate, age at death and duration of illness can either be taken from national level health surveys like NSS rounds (National Sample Survey) in India or from literature/official reports. Our attempt to calculate disease burden using NSS 71st round (2014) unearthed the issue of mortality under-reporting by more than 50 percent. Crude death rate calculated using NSS 71st came out to be 3.1 as of the actual value of 7.0 for India. States known for high disease burden like Bihar ranked lower than healthier states like Kerala (figure 2). The exercise strengthened the issue of high underreporting in national survey thus establishing it unreliable for disease burden estimates.

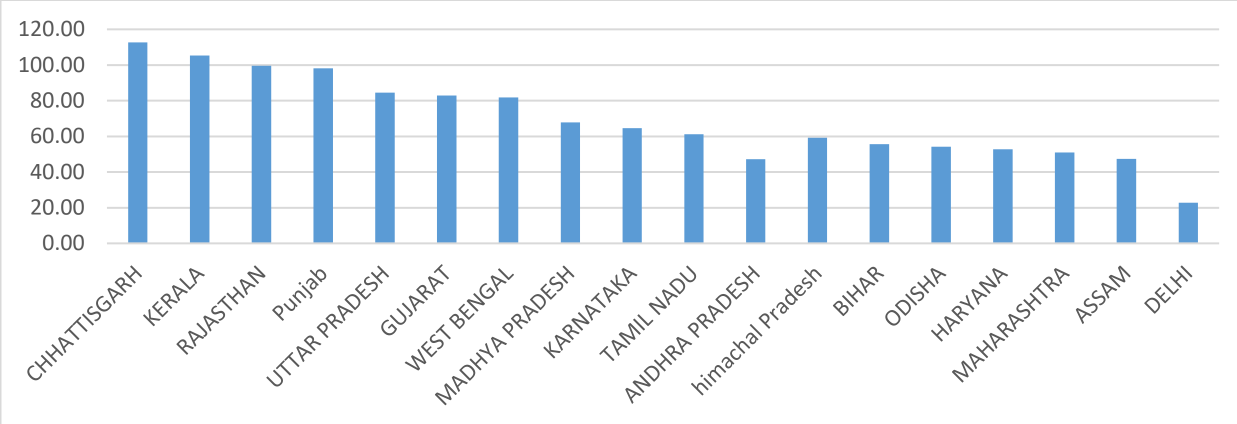

Figure 2: State-wise years of life lost per 1000 in 2014 as per NSS 71st health and morbidity survey

For the mortality data, we turned to Medical certification of cause of death (MCCD) accounts. Instituted in 1969, MCCD reports cause-specific mortality annually obtained under Civil Registration system as per International classification of diseases (ICD). For the year 1995, 2004 and 2014, MCCD accounts for 14.2, 14.2 and 20.5 percent respectively of total reported deaths under civil registration system (Office of Registrar General, 2014). Sample Registration System of births and deaths provides reliable data on total age-sex specific deaths across states and has been used to account for total deaths. Unfortunately, some states did not submit MCCD report for the year of concern hence dropped from the analysis (Uttar Pradesh, Haryana in 2014; Bihar Gujarat, Himachal Pradesh, Punjab, West Bengal in 1995). For self-harm and accidents, mortality data is taken from National Bureau of Crime Records (NBCR) which was instituted in 1986 as a central repository of crime data.

To arrive at total cause-specific mortality, age-sex-cause specific MCCD numbers are projected on age-sex specific total deaths as per Sample Registration System (SRS). While doing so we make an assumption that percentage of under-reported deaths is same across diseases but varies across age.

For the purpose of the study, diseases with the most attributed burden as per GBD 2015 report have been considered. It includes diarrhea, tuberculosis, malaria, lower respiratory infection, peri-natal conditions under communicable and peri-natal conditions; ischemic heart disease, lower respiratory infection, Diabetes, Cancer, Pulmonary heart disease and renal disease under non-communicable; and accidents(natural and unnatural), self-harm under injury. In total, selected diseases account for 55.2, 55.5 and 63.15 percent of total YLL for the year 1995, 2004 and 2014 respectively. The percentage increase in YLL of selected diseases indicates increasing trend in overall diseases burden due to these diseases.

RESULT & ANALYSIS

Life expectancy is a key indicator of population wellbeing. From 1995 to 2014, India's life expectancy increased from 60.44 to 68.01 years. The increase represents India's development in providing better health services and infrastructure. Yet as expected, the spectrum of the disparity between states in bearing burden due to various diseases is widespread. Table 1,2 and 3 presents national burden transition for each disease and decomposed results with and without social weights. Table 4, 5 and 6 enlist states in the order of declining burden (as per 2014) of communicable (and perinatal), non-communicable disease and Injury respectively. 'δ_{Abs}' represents a change in absolute disease burden (in years) between two years while controlling for age structure. 'δ_{Abs}' is further decomposed into a change due to death rate(δ_{DR}), Age at Death(δ_{DA}) and age structure (δ_{AS}).

National Disease Burden Trend

Over the period of two decades, from 1995 to 2014, disease burden continues to decline. Total year loss per thousand because of selected diseases is 196.72, 146.34 and 123.92 in the year 1995, 2004 and 2014 respectively. Disease burden due to communicable (and perinatal) shows a sharp decline from 134.87 to 65.68 between 1995 and 2014(Table 4). Noncommunicable disease burden decline from 48 to 38.34 DALY per thousand from 1995 to 2014(Table 5). Conversely, the burden of Injury soared by 43 percent in these two decades.

Ironically, states with high YLL also reports high age-weighted YLL (Madhya Pradesh, Uttar Pradesh, Haryana, Chhattisgarh, Rajasthan) hinting at high susceptibility to disease among youth (figure 3). High age-weighted YLL is also an indicator of India being at the early stage of epidemiological transition where communicable diseases are still rampant.

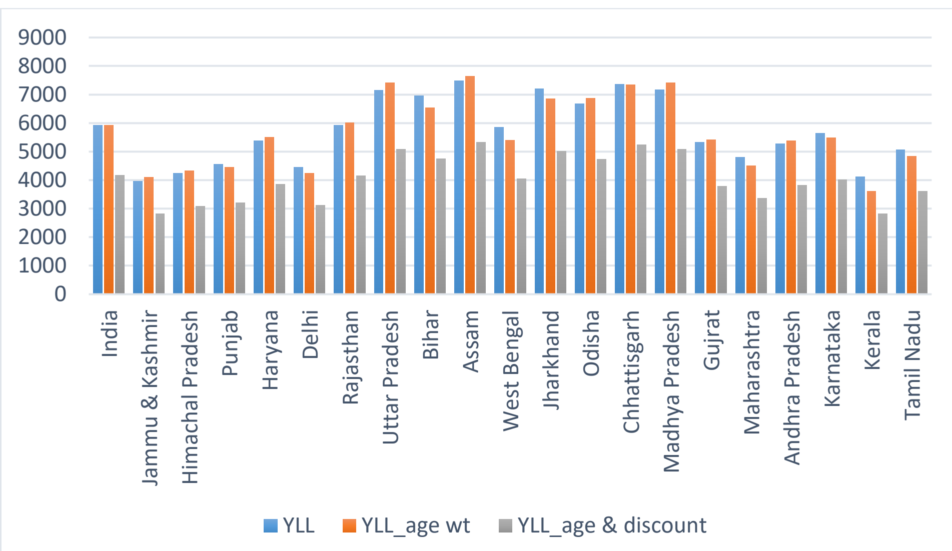

Figure 3 YLL per 1000 for the Indian States in 2014 (Selected diseases; With and without social weights)

Among communicable diseases, only malaria reported increased YLL due to death rate (16.7 percent) between 1995- 2004 while all other death rates declined considerably (Table 1). For Birth trauma, YLL reduced by 11.55 percent due to change in age structure indicating a reduction in fertility rate (Table 1). The death rate due to diarrhea, tuberculosis, and malaria dropped faster between 2004 and 2014 as compared to the previous decade. The surge in YLL due to Age at death dropped from 10.03 to 1.5 percent indicating a reduction in early age deaths (Table 1).

The burden of non-communicable diseases has come down due to a major reduction in death rate except for cancer and lower respiratory infection (LRI)(Table 2). YLL due to Cancer death rate has increased (8.69 % to 10.43%) also accompanied by early age deaths (-15.62 % to -6.78 %)(Table 2). Life loss due to LRI shows trend reversal by turning into positive contributor (11.87%) of YLL from being negative (-49.15%)(Table 2). In case of renal diseases, YLL due to death rate has come down drastically (73.38% to -8.2%) but also reports early deaths (-39.43 % to -19.71 %) (Table 2). If we look at age-weighted disease burden of NCDs, the progress achieved in delaying death is marginally higher from 2004 to 2014 than in the previous decade (-14.39% to -16.89%) (Table 2). For LRI, The difference between age at death and its age-weighted form is around 8 % signifying poor impact of health intervention in early ages. LRI can be categorized as a behavioral disease associated with high rate of smoking.

Table 1 COMMUNICABLE & PERINATAL: Disease burden transition & Decomposition Results 1995-2014

	% change	COMMUNICABLE		Diarrhoea		Malaria		Tuberculosis		Birth Trauma		LRI	
INDIA		1995-2004	2004-2014	1995-2004	2004-2014	1995-2004	2004-2014	1995-2004	2004-2014	1995-2004	2004-2014	1995-2004	2004-2014
	NO SOCIAL WEIGHTS												
	δ DR	-35.01	-23.76	-22.96	-51.49	16.70	-51.99	-32.10	-35.70	-23.88	-13.90	-93.52	-66.01
	δDA	2.06	10.03	-17.37	-9.65	0.80	-8.38	-2.82	-12.19	6.56	11.55	0.56	4.56
	δ AS	-4.35	-8.71	-2.26	-1.48	-2.87	-0.06	0.82	3.26	-6.56	-11.55	-0.56	-4.56
	δAbs	-37.30	-22.44	-42.59	-62.62	14.63	-60.43	-34.10	-44.63	-23.88	-13.90	-93.52	-66.01
	AGE WEIGHTED												
	δ DR	-35.01	-23.76	-22.96	-51.49	16.70	-51.99	-32.10	-35.70	-23.88	-13.90	-93.52	-66.01
	δDA	-2.60	1.50	-20.45	-10.75	0.85	-9.97	-2.35	-14.67	6.56	11.55	0.56	4.56
	δ AS	0.00	0.00	-2.74	-2.30	-3.75	-0.62	0.13	2.49	-6.56	-11.55	-0.56	-4.56
	δAbs	-37.62	-22.27	-46.14	-64.54	13.80	-62.58	-34.32	-47.87	-23.88	-13.90	-93.52	-66.01
	AGE WEIGHTED & TIME DISCOUNTED												
	δ DR	-35.01	-23.76	-22.96	-51.49	16.70	-51.99	-32.10	-35.70	-23.88	-13.90	-93.52	-66.01
	δDA	-1.95	0.75	-16.26	-9.25	-0.70	-7.58	-1.94	-11.62	6.56	11.58	0.56	4.57
	δ AS	0.00	0.00	-2.15	-1.40	-2.49	0.13	0.87	3.32	-6.56	-11.58	-0.56	-4.57
	δAbs	-36.96	-23.02	-41.37	-62.14	13.51	-59.44	-33.17	-44.00	-23.88	-13.90	-93.52	-66.01

While absolute disease burden due to injury shows an upward trend, there is an observed trend reversal in age at death and age structure component. Compared to the previous decade, age at death has become a positive contributor to YLL (-25.19% to 8.82%) signaling young population under the radar of injuries (Table 3).

Table 2 NON-COMMUNICABLE: Disease burden transition & Decomposition Results 1995-2014

	change in %	**NCD**		**IHD**		**LRI**		**Diabetes**		**Cancer**		**Pulmonary Heart Disease**		**Renal Disease**	
INDIA		1995-2004	2004-2014	1995-2004	2004-2014	1995-2004	2004-2014	1995-2004	2004-2014	1995-2004	2004-2014	1995-2004	2004-2014	1995-2004	2004-2014
	NO SOCIAL WEIGHTS														
	δ DR	1.10	-8.72	10.71	-22.47	-49.15	11.87	14.29	-9.10	8.69	10.43	6.52	-9.58	73.38	-8.20
	δDA	-7.16	-14.39	-13.67	-11.69	-14.38	-14.01	-19.91	-8.95	-15.62	-6.78	14.81	-20.86	-39.43	-19.71
	δ AS	4.33	6.17	7.67	7.39	2.76	10.36	7.72	9.12	4.62	6.54	1.66	3.72	4.10	5.66
	δAbs	-1.73	-16.95	4.71	-26.77	-60.76	8.23	2.10	-8.93	-2.31	10.19	22.99	-26.72	38.06	-22.24
	AGE WEIGHTED														
	δ DR	1.10	-8.72	10.71	-22.47	-49.15	11.87	14.29	-9.10	8.69	10.43	6.52	-9.58	73.38	-8.20
	δDA	-6.18	-16.89	-12.95	-13.13	-17.21	-6.11	-23.13	-8.11	-18.08	-4.74	23.89	-25.38	-47.23	-24.35
	δ AS	2.54	4.43	6.46	6.53	0.00	0.00	6.46	8.34	3.09	4.47	-0.64	1.90	1.62	4.06
	δAbs	-2.54	-21.17	4.22	-29.07	-66.36	5.77	-2.38	-8.87	-6.31	10.16	29.76	-33.07	27.77	-28.48
	AGE WEIGHTED & TIME DISCOUNTED														
	δ DR	1.10	-8.72	10.71	-22.47	-49.15	11.87	14.29	-9.10	8.69	10.43	6.52	-9.58	73.38	-8.20
	δDA	-7.65	-14.31	-13.90	-12.22	-12.92	37.32	-21.54	-8.51	-16.33	-6.75	15.56	22.04	-39.62	-19.57
	δ AS	4.11	6.07	7.27	7.20	0.00	0.00	7.27	9.00	4.46	6.56	1.68	3.30	3.92	5.59
	δAbs	-2.44	-16.96	4.08	-27.49	-62.07	49.20	0.03	-8.61	-3.19	10.24	23.76	15.76	37.68	-22.18

Conversely, age structure became a negative contributor to YLL indicating a negative correlation between population age and injuries.There is a major surge of 47.2 %, 22.95% between 2004 and 214 because of accidents (natural or unnatural) and self-harm respectively (Table 3). Marginal or no difference is reported between the weighted and unweighted burden of injuries implying lower burden on youth (age less than 30 years) because of injuries.

Table 3 INJURIES: Disease burden transition & Decomposition Results 1995-2014

	change in %	INJURY		Accidents		Self-Harm	
		1995-2004	2004-2014	1995-2004	2004-2014	1995-2004	2004-2014
INDIA	NO SOCIAL WEIGHTS						
	δ DR	25.44	24.12	7.69	51.53	10.18	24.37
	δDA	-25.19	8.82	-8.13	-11.16	-8.23	-9.36
	δ AS	18.41	-11.86	2.10	6.86	2.77	7.94
	δAbs	18.65	21.09	1.66	47.22	4.73	22.95
	AGE WEIGHTED						
	δ DR	25.44	24.12	7.69	51.53	10.18	24.37
	δDA	-26.46	8.56	-9.41	-11.48	-9.48	-9.45
	δ AS	17.52	-12.52	1.48	5.88	2.26	7.55
	δAbs	16.50	20.17	-0.24	45.93	2.96	22.46
	AGE WEIGHTED & TIME DISCOUNTED						
	δ DR	25.44	24.12	7.69	51.53	10.18	24.37
	δDA	-25.33	8.59	-8.25	-11.35	-8.43	-9.43
	δ AS	18.39	-11.61	2.13	7.18	2.71	8.00
	δAbs	18.50	21.10	1.57	47.35	4.46	22.94

Communicable and perinatal Disease burden

Communicable disease burden has declined invariably across states but with different rates between 1995 and 2014. Bihar has performed poorly with only -5.69 δ_{Abs} and increased death rate (mainly due to diarrhea and tuberculosis)(Table 4). Chhattisgarh is able to bring down communicable disease burden by 75.46 percent from 2004 to 2014(Table 4). Yet, within India malaria mortality continues to be the highest in Chhattisgarh (Bhatt et al, 2012). Among high burdened states, Orissa and Rajasthan have reported slower rate of decline from 2004-2014 as compared to 1995-2004(Table 4). Himachal Pradesh succeeded in reducing burden by 42.12 percent in a later decade but its progress is impeded by 30.45 percent rise in under-five lower respiratory infection death rate (Table available on request). At the national level, malaria δ_{DR} increased by 16.7 percent in 1995 followed by a decline of 52 percent from 2004 to 2014. Overall, India registered 37.3 and 22.4 percent decline in communicable disease burden during 1995-2004 and 2004-2014 respectively(Table 4).

Table 4 Communicable Disease Burden India & States 1995-2014

	STATES	DALY per 1000			1995-2004					2004-2014				
		1995	2004	2014	δ DR %	δDA %	δ AS%	δAbs %	δAbs	δ DR %	δDA %	δ AS%	δAbs %	δAbs
COMMUNICABLE	Madhya Pradesh	204.69	190.67	123.71	-18.01	21.16	-9.77	-6.61	-13.45	-34.68	7.06	-7.57	-35.19	-66.83
	Orissa	151.73	109.56	101.03	-13.66	-8.94	-5.30	-27.91	-42.15	-16.84	19.87	-10.72	-7.70	-8.39
	Rajasthan	175.62	94.03	77.57	-46.31	2.73	-2.95	-46.54	-81.24	-18.05	7.63	-7.11	-17.53	-16.36
	INDIA	**134.87**	**84.69**	**65.68**	**-35.01**	**2.06**	**-4.35**	**-37.30**	**-49.99**	**-23.76**	**10.03**	**-8.71**	**-22.44**	**-18.85**
	Bihar	-	60.46	54.35	-	-	-	-	-	17.32	-23.87	-3.04	-9.59	-5.69
	Karnataka	108.29	80.46	45.88	-25.93	2.72	-2.64	-25.85	-27.80	-37.13	-3.16	-2.91	-43.21	-34.46
	Gujarat	-	78.25	42.41	-	-	-	-	-	-48.56	11.30	-8.53	-45.79	-35.53
	Andhra Pradesh	111.77	56.11	42.05	-45.67	3.25	-7.65	-50.07	-55.61	-31.03	6.56	-3.95	-28.42	-15.76
	Himachal Pradesh	-	62.24	36.13	-	-	-	-	-	-50.70	16.54	-7.96	-42.12	-25.69
	Punjab	-	64.94	32.76	-	-	-	-	-	-42.88	5.07	-12.01	-49.81	-32.10
	Maharashtra	81.12	45.04	26.85	-38.54	-0.99	-5.36	-44.89	-35.99	-37.42	-0.63	-2.56	-40.61	-17.94
	Tamil Nadu	65.04	40.62	26.48	-37.55	7.88	-8.14	-37.81	-24.43	-30.07	-2.44	-2.60	-35.11	-14.11
	Chhattisgarh	-	96.87	23.64	-	-	-	-	-	-69.07	-4.28	-2.12	-75.46	-72.71
	West Bengal	-	39.72	23.05	-	-	-	-	-	-43.91	11.47	-9.62	-42.05	-16.53
	Delhi	-	22.92	20.54	-	-	-	-	-	-5.81	8.31	-13.25	-10.76	-2.42
	Kerala	23.46	12.08	9.90	-52.40	4.53	-1.25	-49.11	-11.33	-20.49	6.32	-3.47	-17.64	-2.07

Non-Communicable Disease burden

As a matter of surprise, Chhattisgarh and Bihar are forerunners in bearing NCD burden. In Chhattisgarh state, there is a sharp increase of 82.94 YLL per 1000 from 2004 to 2014 mainly attributed to pulmonary heart disease(Table 5). The disease is closely linked to the occupational hazard of mining workers (Laney & Weissman, 2014). Bihar reports a high number of deaths due to renal diseases indicating high alcohol and substance abuse in state at a young age. Diabetes at a young age is also on the rise in Bihar which is reflected in 43 percent of absolute YLL change due to lower age at death from 2004-2014. Diabetes prevalence between 12-30 age was assessed and found to be associated with occupation, gender (male) and high Body Mass Index (Tewary et al, 2013).

Tamil Nadu reported maximum progress in reducing NCD burden during 2004 to 2014 mainly attributed to declining of -53.87 $\delta_{DR\%}$ (Table 5). The highest increase in YLL due to age structure change is in the state of Karnataka followed by Punjab and Gujarat. There are several states that are successful in increasing age of death except for Chhattisgarh, Gujarat and Himachal Pradesh(Table 5). In nutshell, the burden of NCD has declined largely because of delayed death and less because of death rate change.

Table 5 Non-Communicable Disease Burden India & States 1995-2014

		DALY per 1000			**1995-2004**					**2004-2014**				
		1995	**2004**	**2014**	δ DR %	δDA %	δ AS%	δAbs %	δAbs	δ DR %	δDA %	δ AS%	δAbs %	δAbs
Non Communicable Diseases	Bihar	-	65.89	60.36	-	-	-	-	-	11.11	-22.08	2.53	-8.45	-5.57
	Kerala	50.17	58.02	53.11	4.14	-1.25	12.04	14.92	7.28	11.66	-16.30	9.31	4.66	2.61
	Chhattisgarh	-	40.21	52.41	-	-	-	-	-	25.81	0.20	5.64	31.65	12.60
	Karnataka	47.35	42.55	50.44	-19.06	3.96	4.96	-10.14	-4.62	32.91	-28.50	13.80	18.20	7.45
	Maharashtra	50.86	43.12	46.26	-7.51	-16.37	7.13	-16.76	-8.26	17.11	-19.16	9.73	7.68	3.15
	Himachal Pradesh	-	45.60	44.52	-	-	-	-	-	-20.74	10.57	10.95	0.78	0.34
	Andhra Pradesh	44.74	55.56	42.79	25.23	-7.70	12.04	29.56	12.76	-11.98	-18.55	10.59	-19.93	-11.14
	Punjab	-	33.70	38.99	-	-	-	-	-	20.45	-15.08	11.89	17.26	6.41
	INDIA	**48.00**	**47.44**	**38.34**	**1.10**	**-7.16**	**4.33**	**-1.73**	**-0.81**	**-8.72**	**-14.39**	**6.17**	**-16.95**	**-7.76**
	Rajasthan	50.57	43.62	37.50	-9.28	-5.66	3.58	-11.36	-5.61	-1.34	-17.67	8.43	-10.57	-4.63
	West Bengal	-	58.08	34.02	-	-	-	-	-	-28.05	-16.74	6.31	-38.49	-22.56
	Gujarat	-	28.74	31.69	-	-	-	-	-	0.01	1.23	10.53	11.76	3.24
	Tamil Nadu	52.42	70.97	31.48	-0.23	24.83	10.29	34.89	17.72	-53.87	-4.77	3.36	-55.27	-37.87
	Orissa	42.74	28.70	30.90	-23.59	-12.37	7.33	-28.63	-11.97	9.66	-10.80	7.56	6.42	1.92
	Madhya Pradesh	57.14	36.78	29.36	-44.45	4.31	1.24	-38.90	-22.75	-9.08	-15.98	4.51	-20.55	-7.34
	Delhi	-	27.90	17.29	-	-	-	-	-	-23.58	-16.43	7.45	-32.55	-8.99

Burden of Injuries

In absolute value, two centrally located states are bearing highest injury burden. As per NCRB report, Chhattisgarh reports the highest rate of both natural and unnatural death due to poisoning, drowning, and fire. In Maharashtra, self- harm at young age and accidents are on continuous rise attributing to 63.99 % increase in burden during 2004-2014(Table 6). Change in burden due to age at death is minimal in all states except Delhi indicating high burden on the young population.

Table 6 Non-Communicable Disease Burden India & States 1995-2014

	STATES	DALY per 1000			1995-2004					2004-2014				
		1995	**2004**	**2014**	δ DR %	δDA %	δ AS%	δAbs %	δAbs	δ DR %	δDA %	δ AS%	δAbs %	δAbs
	Madhya Pradesh	19.12	21.58	42.98	-21.72	32.89	1.70	12.87	2.46	26.48	-6.93	9.41	28.96	21.40
	Chhattisgarh	-	29.68	40.69	-	-	-	-	-	28.68	-8.82	6.48	26.33	11.01
	Maharashtra	30.90	24.69	30.24	-14.73	-8.23	2.84	-20.12	-6.22	66.54	-8.49	5.93	63.99	5.55
	Tamil Nadu	18.44	19.54	28.94	15.69	-11.82	2.09	5.96	1.10	80.76	-15.56	10.15	75.35	9.39
	Delhi	-	21.84	27.60	-	-	-	-	-	252.57	-163.60	10.19	99.17	5.75
	Gujarat	-	16.31	25.19	-	-	-	-	-	27.27	-8.39	4.46	23.34	8.88
	Karnataka	21.32	19.76	24.37	-1.63	-8.34	2.66	-7.31	-1.56	33.59	-8.19	5.67	31.06	4.61
	Himachal Pradesh	-	14.35	23.53	-	-	-	-	-	-	-	-	0.00	9.18
	Andhra Pradesh	11.09	17.44	22.86	68.16	-18.71	7.84	57.29	6.35	39.04	-7.79	5.83	37.08	5.42
	Rajasthan	13.28	15.94	20.55	32.24	-13.07	0.86	20.03	2.66	40.47	-11.11	6.69	36.05	4.61
	Kerala	18.71	17.52	20.39	-54.07	44.67	3.02	-6.38	-1.19	59.63	-10.16	4.99	54.46	2.88
	INDIA	**13.85**	**14.20**	**19.90**	**25.44**	**-25.19**	**18.41**	**18.65**	**2.58**	**21.03**	**-4.17**	**-0.44**	**16.42**	**3.47**
	Orissa	10.27	12.76	19.75	31.93	-10.81	3.14	24.26	2.49	24.12	8.82	-11.86	21.09	6.99
	Punjab	-	10.30	18.06	-	-	-	-	-	55.16	-5.72	5.37	54.81	7.76
	West Bengal	-	12.34	16.79	-	-	-	-	-	123.47	-12.77	10.08	120.79	4.45
INJURY	Bihar	-	2.75	6.08	-	-	-	-	-	25.74	-6.47	3.21	22.49	3.33

DISCUSSION

The study not only attempts to estimates disease burden estimate but also suggest on the methodology of impact analysis of health progression. There is a net decline of 37 percent in disease burden due to selected diseases during 1995-2014. Among communicable, Malaria, diarrhea and lower respiratory infection reported a maximum decline in death rate during 2004-2014 than in a previous decade. The progress can be linked to ambitions National Health Mission initiated in 2004 primarily to reduce under 5 mortality. NCDs burden illustrates the net decline in burden but cancer and lower respiratory infection reports higher burden. Burden due to injury followed an upward trend in both the decades. According to NCRB report, the main cause of self-harm during the mid-1990s was prolonged illness. Hence it is not improper to state that 1995-2004 witnessed a decline in self-harm burden primarily due to access to better health facilities. An alarming increase in accidental death burden by 47.22 % during 2004-2014 is a matter of concern as it affects workgroup population the most.

Comparative assessment of states toss some unpleasant results for states like Bihar (Northern state) which seems to bear dual burden of communicable and NCD both. The dominant cause of high NCDs burden in Bihar is young age diabetes and renal diseases which is a reflection of high substance abuse in the state. Young individuals acquiring NCDs in a state like Bihar is a matter of concern since India's economic edge is its young demography.

State of Chhattisgarh (central state) achieved impressive results in reducing communicable disease burden during 2004-2014 yet it ranks among top five in NCDs and injury burden list. Similarly, Tamil Nadu (southern state) achieved a remarkable decline in NCD death rate, especially among youth adults. On the contrary, Karnataka (southern state) absolute NCD burden increased by 18.2 percent in a later decade. This number overestimates the progress of Karnataka's health system. State's NCD burden due to death rate has increased by 32.91 percent with 13.8 percent burden rise due to age structure transition. The decomposition method, thus, allows extraction of policy impact by removing confounding effect of age structure transition. It is recommended to include this practice in future assessment studies.

With these results in hand, there is a need to extend the study further for an associated risk factor for each disease. For example, mining intensive states like Chhattisgarh and Bihar have come up in the ranking of non-communicable diseases and are bearing the dual burden. While Maharashtra, Kerala, and Karnataka might have high NCD burden owing to other risk factors like smoking, sedentary lifestyle etc. Hence it is essential to understand the disparity in risk factors along with disease burden disparities.

Also, to improve regional estimates we felt the need for better reporting and record keeping. MCCD only accounts for 20 percent of the total registered deaths and many major states like Uttar Pradesh, Haryana is sporadic in submitting MCCD reports. We observed better data repository of the centrally designed disease control program as compared to state reports. There is a need for better health information system management at the state level as well to improve the accuracy of estimates.

Our study is among early work in the direction of local disease burden estimation. The results should be of interest to regional program designers and implementers. Findings of the study would be useful in tailoring health care expenditures at regional level based on population health needs thus improving technical and allocative efficiency of health systems.

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