BMJ Open

Age and sex pattern of premature mortality in India

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2014-005386
Article Type:	Research
Date Submitted by the Author:	02-Apr-2014
Complete List of Authors:	Dubey, Manisha; International Institute for Population Sciences , MOHANTY, SANAJY; International Institute for Population Sciences, Department of Fertility Studies
Primary Subject Heading:	Public health
Secondary Subject Heading:	Public health, Research methods, Health policy, Health informatics
Keywords:	Public health < INFECTIOUS DISEASES, Coronary heart disease < CARDIOLOGY, PUBLIC HEALTH, Demography < TROPICAL MEDICINE

Title: Age and sex pattern of premature mortality in India

Authors: Manisha Dubey[1] and Sanjay K Mohanty[2]

Corresponding author:
Manisha Dubey, International Institute for Population Sciences (IIPS), Govandi Station Road, Deonar, Mumbai-400088, India; Mobil-9757224808, Email: manikvdlw@gmail.com

Institutional Affiliation:
[1] Research Scholar, International Institute for Population Sciences, Govandi Station Road, Deonar, Mumbai-400088, India; Mobil-9757224808, Email: manikvdlw@gmail.com, manisha.iips@gmail.com
[2]Professor, Department of Fertility Studies, International Institute for Population Sciences, Govandi Station Road, Deonar, Mumbai-400088, India; Mobil-9969687529, Email: sanjayiips@yahoo.co.in, sanjay@iips.net

Keywords: Premature mortality, YPLL, PYPLL, WYPLL, Causes of death

Word count: 3315

Abstract

Background: Demographic and epidemiological transition in India has resulted in large working age population and rise in non-communicable diseases at faster pace than predicted. Early onset of non-communicable diseases are primarily affecting the working age population those are premature and avoidable. Using data from multiple sources this paper examines the age and sex pattern of premature mortality in India.

Methods: The premature mortality is measured with a set of indices; years of potential life lost (YPLL), premature years of potential life lost (PYPLL) and working years of potential life lost (WYPLL). All the indices were standardised and their corresponding rates have been calculated for broad age groups from 1991 to 2011 and also by selected causes of death for 2002.

Results: During 1991-2011, the age-standardized rate of YPLL had declined from 310to 235.2 for male and from 307 to 206 for females per 1000 population. The standardized PYPLL (per 1000 population in 0-65 age) has declined from 259.4to 136.9for males and from 257.6to 115.2 for females during the same period. The standardized WYPLL has declined from 274.2to 130.7 for males and from 294.8to 90.6 for females. Though the age pattern of these indices suggests significant improvement in early childhood mortality, PYPLL and WYPLL both are maximally contributed by the age group 0-4 years among both male and female. Afterwards, it decline in the age group 5-14 years but again increases among adults e.g. 15-65 years. In 2002, the WYPLL due to cardiovascular diseases was 25.7 million among males and 14.7 million among female.

Conclusion: The increasing share of premature mortality among adults and slower pace of decline in overall premature mortality during 1991-2011 warrants the urgent need to devise strategies on prevention and treatment of non-communicable diseases to save premature deaths in India.

Strengths and limitations of this study:

This is the first ever study that provides the standardised estimates of premature mortality (YPLL, PYPLL and WYPL) by age and sex in India over two decades. It also estimates the standardised indices by cause of death. However, the study has two main limitations. First, it could not provide the state level estimates of the indices as the data on cause of death was available only at national level. Second, the trends in cause specific estimates could not be carried out due to data constraints.

Age and sex pattern of premature mortality in India

Introduction

Prevention of premature deaths and improving the adult health is increasingly the major public health challenges in developing world. This is largely due to the demographic and epidemiological transition that has altered the level of mortality and disease pattern across the age groups [1, 2]. The Non-communicable Diseases (NCDs) are the leading cause of death and it is primarily affecting the working age group [3, 4]. Studies suggest that premature deaths and hospitalisation adversely affects economic growth [5-7]. Mahal [7] estimated one trillion rupees loss of GDP in 2004 due to Cardiovascular Disease (CVD) in India.

The concept of premature mortality was evolved to measure the increasing social and economic cost of mortality at younger age because the conventional measure such as crude death rate and age specific death rate does not quantify the extent of life years lost at early ages[8]. A number of measures are developed and used to quantify the extent of premature mortality. These includes preferably potential years of the life lost (PYLL), premature years of potential life lost (PYPLL), the working years of potential life lost (WYPLL) and the valued years of potential life lost (VYPL). Each of the method is a function of age at death and the number of deaths at that age [9]. However, they varied with respect to upper and lower limit and weight given to each age.

Romeder and McWhinnie [10]rank the major cause of premature mortality by focussing on PYLL in age group 1 and 70.The level, pattern and cause of adult mortality in selected developing countries has been estimated, also the YPLL using an age-weight of 85 years minus the age at death[11].The Organisation of Economic Cooperation and Development [12]measured premature mortality with the help of potential years of the life lost (PYLL) before age 70 years for its member nations. According to a report issued by the US General Accounting Office in 1996, “premature mortality is the best single proxy for reflecting differences in the health status of state’s populations”[13]. The potential years of life lost (PYLL) is the most commonly used indicator to quantify premature mortality. In 2009, the PYLL was 201 per 1000 males in Russian Federation (highest) followed by Newzeland (89). The gender differentials are large, higher for male than females (71 per 1000 females in Russian Federation and 28 in Newzland). A study on the fall and rise in inequalities in

premature mortality(death before the age 65) in USA for 1960-2002 found that the premature mortality and infant mortality decreased for all income groups[14]. The expected years of life lost has been estimated to rank the leading cause of deaths in San Francisco [15]. Large health disparities between African American and other ethnic groups were found. Disparities in premature mortality between high and low income countries and found strong association of income and premature mortality in low income countries than high-income countries and the risk factors are different for each group [16].

The non-communicable diseases (NCDs) account for 62% of the total burden of foregone DALYs and 53% of total deaths in India.9.2 million productive life lost in India in 2000 due to CVD among 35-64 years age group were estimated and projected to 17.9 million by 2030 [17]. The cardiovascular deaths (CVDs) was estimated as1.4 million (56.2% in 25-69 age group) in 2004 and projected at 2.1 million (45% in 25-69 age group) by 2021[18].The hospitalisation rate and outpatient visit due to NCDs rose from 32% to 40% and 22% to 35%, respectively, within a decade from 1995 to 2004 [19]. In this context it is necessary to understand the extent of deaths among working population in India.

Like other developing countries, India is also experiencing rapid demographic and epidemiological transition. While the total fertility rate is close to replacement level, the life expectancy has reached to 64.6years for male and 67.7 years for female by 2008 [20]. There has been significant reduction of child mortality in last two decades. The share of child mortality to total deaths has declined from 35% in 1991 to 17% by 2011. However, the share of adult deaths (deaths between 15-59 years) is on the rise though the probability of death between 15-59 years has declined over time. The Non-communicable diseases are the leading cause of mortality and morbidity. In this context, this paper examines the age and sex pattern of premature mortality in India over last two decades (1991-2011). It also estimates the extent of premature mortality by selected causes of death for 2002. The paper has been conceptualised with following rationale. First, the on-going demographic and epidemiological transition in India has altered the disease pattern and also the social, psychological and economic costs associated with premature deaths are devastating. The NCDs are the leading cause of deaths which are more prevalent among adults. Hence prevention of these deaths must be a public health priority. Second, the onset of NCDs in India is 10-15 years earlier than that of developed countries. These deaths are primarily affecting the working age group which results into rise in premature mortality and the public

health centres in India are not equipped enough to treat the NCDs. Third, though the premature mortality has been extensively studies in developed countries, there is no study that has estimated the level and trend of premature mortality in India. The quantification of premature mortality helps to identify the social and economic cost associated with mortality, ranks the disease burden and has greater policy relevance. In this context, this paper provides the numerical estimates on the premature deaths in India over time and by causes of death for broad age group.

Data

This paper uses data from multiple sources; the census of India, 1991, 2001 and 2011, the sample registration system (SRS), 1991-2011 and report on cause of death, 2001-03 [21-25]. This paper used published data and does not have any ethical issues. This is an independent research and did not get any funding. The Indian census is the largest single source of information on different characteristics of the people of India. We have used the age and sex distribution of the population for 1991, 2001 and 2011 census and the intercensal population for 1996 and 2006. The age distribution of intercensal periods (1996 and 2006) are borrowed from SRS.

The data on causes of death is extremely useful for planning of health programmes and for planning evidence based interventionist strategies in the country. The special survey of deaths (SSD was undertaken by SRS in early 2004-05) using an advanced form of verbal autopsy for the period 2001-03.The Office of the Registrar General, India (ORGI) has prepared this Report jointly with the Centre for Global Health Research (CGHR), St. Michael's Hospital, and University of Toronto [21]. The grouping for the Causes of Death is as per the World Health Organisation (WHO) guidelines. The SSD was implemented during 2004-05 covering all deaths from 2001-2003 in Sample Registration System (SRS) [21]. The causes of death have been determined using an advanced form of Verbal Autopsy called the "RHIME" or Representative, Re-sampled, Routine Household Interview of Mortality with Medical Evaluation method. The cases resulting into continuing disagreements were referred to a third physician to adjudicate the final ICD-10 code. We have used data on distribution of deaths by age, sex and cause from this report to estimate the premature mortality due to individual causes of death.

Methodology

Three indices have been used to quantify the premature mortality in India as described below:

a. Years of Potential Life Lost (YPLL)

The potential years of life lost (YPLL) is a summary measure of premature mortality that gives higher weight to deaths occurring at younger age. It involves estimating the average time a person would have lived had he or she not died prematurely[9].The method used in this study is given by:

$$YPLL = \sum_{i=0}^{\infty} d_i * L_i \quad (1)$$

whereL_i is the life expectancy at age i, d_i is the number of deaths at age i.

The standardised YPLL and corresponding rates have been calculated as follows[10]:

$$\text{Standardized YPLL} = YPLL * \left(\frac{P_{i,r}}{N_r}\right) * \left(\frac{N}{P_i}\right) \quad (2)$$

where$P_{i,r}$ is population in the i^{th} age group in the reference population (Kerala);

$N_r$is the total reference population (Kerala)

N is the total study population;

$P_i$is the population in the i^{th} age group in the study population.

$$\text{Rate of YPLL} = \frac{\sum YPLL}{N} * 1000 \quad (3)$$

b. Premature years of potential life lost (PYPLL)

PYPLL measures the loss of years of productive life due to death before a cut-off age. Different age limit could be taken to define premature death, however many studies have considered death before age 65 years as premature death[9].

$$PYPLL = \sum_{i=0}^{N} d_i * (N - i) \quad (4)$$

whered_i is the number of deaths at age i,

We have used 65 as the upper cut-off age.

$$\text{Standardized PYPLL} = PYPLL * \left(\frac{P_{i,r}}{N_r}\right) * \left(\frac{N}{P_i}\right) \quad (5)$$

Where $P_{i,r}$ is population in the i^{th} age group in the reference population (taken as Kerala);

N_r is the total reference population in age group 0 to 65 (taken as Kerala);

N is the total study population in age group 0-65;

P_i is the population in the i^{th} age group in the study population.

$$\textbf{Rate of PYPLL} = \frac{\sum PYPLL}{N} * 1000 \quad \textbf{(6)}$$

Where N is the total population in age group 0 to 65.

c. Working years of potential life lost (WYPLL)

The WYPLL measures the working life years lost during "the working age period" in a population.

$$WYPLL = \sum_{i=0}^{W-1} d_i * (N - W) + \sum_{i=W}^{N} d_i * (N - i) \quad \textbf{(7)}$$

Where d_i is the number of deaths at age i,

N is the upper cut off age;

W is the lower cut-off age.

In computing the WYPL, the lower limit of 14 and upper limit of 65 is taken.

$$\textbf{Standardized WYPLL} = WYPLL * \left(\frac{P_{i,r}}{N_r}\right) * \left(\frac{N}{P_i}\right) \quad \textbf{(8)}$$

Where $P_{i,r}$ is population in the i^{th} age group in the reference population (taken as Kerala);

N_r is the total reference population in age group 0 to 65 (taken as Kerala);

$N$is the total study population in the age group 0 to 65;

P_i is the population in the i^{th} age group in the study population.

$$\textbf{Rate of WYPLL} = \frac{\sum WYPLL}{N} * 1000 \quad \textbf{(9)}$$

Where N is the total study population in the age group 0 to 65 years.

Cause specific indices of premature mortality

We have also computed the YPLL, PYPLL and WYPLL were calculated for selected causes of death using the above methods for 2002. The diseases specific deaths are taken from the distribution of death by cause, age and sex and taken from Report on Causes of Death, RGI, 2001-03.

Results

Results are presented in two sections. Section 1 describes the level and trend of premature mortality by age and sex and section 2 presents the estimated years of premature deaths by causes of death.

Indices of Premature Mortality, 1991-2011: YPLL, PYPLL and WYPLL

Table 1 presents the standardized YPLL in millions for a period of two decades (1991-2011) by broad age group and sex. During 1991-2011, the YPLL has increased from 134.1 million to 146.6 million among male while it has declined from 123.2 million to 107.9 million among females. The rate of YPLL has declined from 310 to 235.2 per 1000 population for males and from 306.9 to 206 for females in the same period. Though the overall decline in YPLL reflects the marked improvement in mortality in the population, it conceals large discrepancies in broad age group. The decline in YPLL was significant among younger age group, particularly among children while it has remained similar or increased among adults (15-64 years). Among children under five years of age, the YPLL has declined from 56.3 in 1991 to 35 by 2011 for male while among female it has declined from 53.1 to 36.3among female in the same period. Among adults (in 15-64 age groups), the YPLL has increased during 1991-2011 for males in all the age group, for example, in 60-70 age group YPLL has increased from 13.4 million to 20 million and from 12.6 to 18.7 million in the 30-45 age group .The YPLL has increased from 22.5 million in 1991 to 28.2 million by 2011 in the 45-59 age group. Among adult females, the YPLL has declined in the age group 15-45 and increased in the age group 60-70. With respect to elderly, the rate of YPLL has declined from 10.5 in 1991 to 26.8 by 2011 for males and 11.5 to 27.4 for females.

Table 1: Standardised years of potential life lost (YPLL) in million and rate of YPLL (per 1000 population), India

Age group	1991		1996		2001		2006		2011	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0-4	56.3	53.1	50.2	48	62.3	60.4	45	41.5	35	36.3
5-14	7.8	7.9	7.9	8.3	7.3	7	7.2	6.8	5.6	5.0
15-29	10.9	13.2	11.3	13	13.1	14.7	13.1	12.9	12.2	11.2
30-45	12.6	11.9	14.4	12.5	17.4	13.6	18.2	12.5	18.7	10.6
45-59	22.5	14.9	24.6	17.2	28.1	18.7	26.5	16.7	28.2	16.9
60-70	13.4	10.8	17.1	13.5	18.4	14.6	18.6	15	20	15.1
70+	10.5	11.5	20.2	23	18.4	12.4	23.8	50.5	26.8	30.7
Total	134.1	123.2	145.7	135.3	165	141.3	152.5	155.8	146.6	107.9
Rate	310	306.9	302.8	302.4	311	285.4	264.6	288.8	235.2	206

Table 2 provides the premature years of potential life lost (PYPLL) by age and sex in last two decade. The PYPLL fixes an upper limit to which individual are expected to survive and

measures the loss of years of productive life due to death before a selected cut-off age. During 1991-2011, the estimated PYPLL for male has declined from 107.7 to 80.9 million while that of females has declined from 99.1 to 63.8 million. The rate of PYPLL among male has declined from 259.4 in 1991 to 224.2 in 2001 and further to 136.9 by 2011. Among females, the rate of PYPLL has declined from 257.6 in 1991 to 212.9 in 2001 and 115.2 in 2011. The decline in PYPLL is faster among females compared to males. The differentials in PYPLL by age groups suggest that the decline is largely contributed by younger age group, particularly children under five years of age. During 1991-2011, the YPLL among children under five years of age has declined from 63.8 million years to 34.9 million years for male and from 60.1 million to 34.5 million years for females. The decline was secular for both male and females. On the other hand, in age group (15-65), the PYPLL has declined for females but not for males. The PYPLL for males in the age group 30-45 has increased from 10.8 million years to 14.2 million years and that for 45-59 it has increased from 13.6 million to 14.4 million years. Much of the gain in PYPLL was due to improvement in younger ages (below age 15 years and less at adult ages. In all the years studied, the PYPLL among male was highest in 0-4 age group followed by age group 45-59 years. Similarly for females the PYPLL was highest in 0-4 age group followed by 15-29 age group. While declining in PYPLL among children is a good sign, the increase in these indices among adult in the prime working age group is a concern. This is possibly due to increase in non-communicable diseases that are largely affecting the prime working age groups.

Table 2: Premature years of potential life lost (PYPLL) in million and rate of PYPLL (per 1000 population), India

Age group	1991		1996		2001		2006		2011	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0-4	63.8	60.1	54	51.2	65.5	61.9	46.1	41.1	34.9	34.5
5-14	7.8	7.7	7.5	7.7	6.7	6.4	6.7	6	5.1	4.3
15-29	10.4	12.2	10.2	11.3	11.7	12.3	11.5	10.7	10.5	9.0
30-45	10.8	9.6	11.6	9.4	13.6	9.9	14	8.9	14.2	7.3
45-59	13.6	8.5	13.4	8.7	14.5	8.8	13.7	7.8	14.4	7.6
60-65	1.3	0.9	1.6	1.1	1.4	1	1.6	1.1	1.6	1.0
Total	107.7	99.1	98.3	89.4	113.6	100.1	93.6	75.5	80.9	63.8
Rate	259.4	257.6	212.6	208.8	224.2	212.9	170	147	136.9	115.2

Table 3 presents the working years of potential life lost (WYPLL) by age and sex for last two decades. The WYPLL gives a higher weightage to working age population. During 1991-2011, the WYPLL has declined from 113.84 million to 77.2 million among male and from 113 million to 45 million among females. The rate of WYPLL has declined from 274.2 in 1991 to 130.7 per 100 for males. Among females, the rate of WYPLL has declined from

294.8 in 1991 to 90.6 in 2011. Distribution of WYPLL by age over the period of time shows similar pattern as that of YPLL. Among females, the WYPLL has declined over all age group while for males it has declined only for younger age group. Among males aged 30-45 years, the WYPLL has increased from 9 million years in 1991 to 13.1 million years by 2011. The WYPLL was higher among females compared to males at all age group. The standardisation of WYPLL does not change the gradient across age and sex over the period of time but level has changed.

Table 3: Working years of potential life lost (WYPLL) in million and rate of WYPLL (per 1000 population), India

Age group	1991		1996		2001		2006		2011	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0-4	73.4	76.9	61.3	63	72.3	74.8	47.9	46	34	36.4
5-14	10.3	11.4	9.8	10.9	8.7	8.9	8.0	7.8	5.7	5.3
15-29	8.7	10	8.5	9.3	10.0	10.2	10.2	9.3	9.7	8.1
30-45	9.0	7.7	9.7	7.8	11.6	8.3	12.4	7.7	13.1	6.5
45-59	11.4	6.8	11.3	7.1	12.4	7.2	12.2	6.8	13.2	6.8
60-65	1.1	0.8	1.4	0.9	1.2	0.8	1.4	1.0	1.5	0.9
Total	**113.8**	**113**	**102.2**	**99**	**116.3**	**110**	**92.1**	**78**	**77.2**	**45**
Rate	274.2	294.8	220.9	231.5	229.6	234.3	167.3	152.8	130.7	90.6

YPLL, PYPLL and WYPLL by causes of death

Table 4 and figure 1, 2 and 3 presents the indices of premature mortality by causes of death for male and female. Given the increase in adult mortality, we have taken top nine causes of death among adults and computed the indices of premature mortality YPLL, PYPLL and WYPLL. These indices were limited to the year 2002 because the causes of death data were available only for this period. Among the nine leading causes of death, CVD account for maximum loss in YPLL and WYPLL.

The WYPLL among males was 25.7 million due to CVDS followed by 12.1 million due to Tuberculosis and 11.5 million due to Diarrheal diseases. The rate of WYPLL among males was also maximum for CVDs (49.6) followed by Tuberculosis (23.3) and diarrheal diseases (22.2). Similarly, for females, the WYPLL was highest for CVDs (14.7 million) followed by Diarrheal diseases (14.1) and malignant and other neoplasms (8.5). Among males, the YPLL was highest for CVDs (20.7) followed by diarrheal diseases (11.6) and Tuberculosis (9). For females, the YPLL was highest for CVDs (16.8) followed by diarrheal diseases (8.9) and Respiratory diseases (8.1). In terms of PYPLL, among males, the rate was highest for diarrheal diseases (9.1) followed by CVDs (7.6) and accidents (6.6). In case of females also, the rate of PYPLL was highest due to diarrheal diseases (11) followed by CVD (4.5) and

accidents (4.2). The corresponding rate of the YPLL, PYPLL and WYPLL shows the same trend for the given causes of deaths.

Table 4: Rate and absolute number of YPLL, PYPLL and WYPLL by cause, India,2002

Causes of death	Rate (per 1000 population)						Absolute number (million)					
	YPLL		PYPLL		WYPLL		YPLL		PYPLL		WYPLL	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Tuberculosis	16.7	13	9.7	7.7	23.3	14.2	9	6.6	5	3.7	12.1	6.8
Diarrheal diseases	21.4	17.6	17.6	23.0	22.2	29.4	11.6	8.9	9.1	11.0	11.5	14.1
Malaria	7.9	7.8	5.9	7.2	8.8	10.4	4.3	4	3.1	3.5	4.6	5
Malignant and other neoplasms	11.9	14.6	6.2	7.1	16.4	17.8	6.4	7.3	3.2	3.4	8.5	8.5
CVD	38.2	33.3	14.6	9.5	49.6	30.7	20.7	16.8	7.6	4.5	25.7	14.7
Respiratory diseases	15.5	16	4	3.3	18.3	13.5	8.4	8.1	2.1	1.6	9.5	6.5
Digestive diseases	9.7	5.9	5.9	3.8	13.2	6.9	5.2	3	3.1	1.8	6.9	3.3
Unintentional injuries: Other Accidents	16.1	10.4	12.7	8.8	17.9	12.3	8.7	5.2	6.6	4.2	9.3	5.9
Intentional injuries: Suicide	7.3	7.3	5.8	5.8	8.6	7.1	3.9	3.7	3	2.8	4.5	3.4

Figure 4 and 5 depicts the age pattern of WYPLL for top three causes of death among male and female respectively. It is clear from both the figures that the Diarrheal diseases accounts for majority of the years lost among children (0-14 years) whereas CVD accounts for the highest life years lost among adults and old population. The adult population is affected by both communicable and non-communicable diseases. For example, among males, CVD and Tuberculosis both are remarkably high in the adult ages. Similarly, among adult females, CVD and Malignant and other neoplasms are leading causes of premature mortality. Hence, the adults of India are facing the dual burden of diseases which leads to the increase in premature mortality and lowering their health status.

Conclusion

The concept of premature mortality has been used as an important measure of health status and a guide for health policies. Though the overall premature mortality indices and their rates have declined over time, the age pattern of YPLL, PYPLL and WYPLL reflects increased in premature mortality among male adults and older population. The decline in premature mortality is largely due to improvement in mortality in the younger age group e.g. 0-14 years. Males are experiencing more years of life lost than females. The indices have shown declining trend for adult females but has increased for males during 1991-2011. Analysis by causes of death depicts that there are certain diseases which remarkably accounts for more years of life lost than others. YPLL was highest due to CVD followed by Diarrheal diseases and Tuberculosis and Respiratory diseases for both male and female. Diarrheal diseases

accounts for highest loss in PYPLL followed by CVD and Accidents for both sex. The CVD accounts for highest loss in WYPLL both male and female followed by Tuberculosis and Diarrheal diseases for males and Diarrheal diseases and Malignant and other neoplasm for females. As most of the CVD deaths are premature and affecting the prime working age groups, it is time to invest and devise strategies to combat the non-communicable diseases particularly those are avoidable in working age groups. Diarrheal diseases, Tuberculosis and Malignant and other neoplasm are the other treats to young population which are communicable in nature. The dual burden of diseases on India is the root cause of poor health status of the population as signified by the indices of premature mortality. Therefore, the increasing share of premature mortality among adults and slower pace of decline in overall premature mortality during 1991-2011 warrants the urgent need to devise strategies to combat the dual burden of diseases and save premature deaths in India.

Though many new indices have been developed to measure the premature mortality like DALY (Disability adjusted life years), HALY (Health adjusted life years), YLL (Years of life lost) etc., these are based on a number of assumptions and suffers from data limitations in Indian context. On the other hand, the YPLL, PYPLL and WYPLL are simple to compute and capture the premature mortality as it is based on fewer assumptions and data input.

Summary box

What is already known on this object?

The demographic and epidemiological transition inIndia has resulted increase in non-communicable diseases across socio-economic groups and space. Studies suggest increase in premature mortality in prime working age group. A number of indices were devised to measure the extent of premature mortality; Years of life lost, Potential years of life lost, Working years of life lost, Valued years of life lost, Years of life lost and deaths among persons under age 65 etc. Though a number of indices were developed to measure the extent of premature mortality, these were limited to developed countries.

What does this study add?

This study adds to the available literature on premature mortality by providing the standardised estimates of premature mortality by age and sex in India over two decades. It also suggests that the premature mortality is on rise among men in prime working age group. The cardiovascular disease is the leading cause of premature mortality followed by diarrheal diseases.

Author's Contribution: MD conceptualised and prepared tables. MD and SKM prepared analytical plan and drafted the paper.

Data sharing: No additional data available.

Competing Interests: None

References

1 Joshi R, Cardona M, Iyengar S*, et al.* Chronic diseases now a leading cause of death in rural India--mortality data from the Andhra Pradesh Rural Health Initiative. *International journal of epidemiology* 2006;**35**:1522-9.

2 Quigley MA. Commentary: shifting burden of disease--epidemiological transition in India. *International journal of epidemiology* 2006;**35**:1530-1.

3 Upadhyay RP. An overview of the burden of non-communicable diseases in India. *Iranian journal of public health* 2012;**41**:1-8.

4 Goyal A, Yusuf S. The burden of cardiovascular disease in the Indian subcontinent. *The Indian journal of medical research* 2006;**124**:235-44.

5 Bloom DE, Canning D. Health and Economic Growth: Reconciling the Micro and Macro Evidence. *CDDRL WORKING PAPERS*. Stanford: Stanford University 2005.

6 Bloom DE, Canning D, Sevilla J. The Effect of Health on Economic Growth: A Production Function Approach. *World Development* 2004;**32**:1-13.

7 Mahal A. The poor and health service use in India. *Health, Nutrition and Population (HNP) Discussion Paper*. The World Bank: Washington, DC 2001.

8 Dempsey M. Decline in tuberculosis: the death rate fails to tell the entire story. *Am Rev Tuberculosis* 1947;**56**:157-64.

9 Gardner JW, Sanborn JS. Years of potential life lost (YPLL)--what does it measure? *Epidemiology (Cambridge, Mass)* 1990;**1**:322-9.

10 Romeder JM, McWhinnie JR. Potential years of life lost between ages 1 and 70: an indicator of premature mortality for health planning. *International journal of epidemiology* 1977;**6**:143-51.

11 Murray CJL, Yang G, Qiao X. Adult mortality: levels patterns and causes. In: DT J, RG F, MW M, eds. *The Health of Adults in the Developing World*. New York: Oxford University Press for the World Bank 1992.

12 OECD. Premature mortality. *Health at a Glance 2011: OECD Indicators*. OECD Publishing: Organisation of Economic Cooperation and Development 2011.

13 Scanlon WJ. A Health Status Indicator for Targeting Federal Aid to States. In: Fastrup J, ed. *Report to the Chairman, Committee on Labor and Human Resources, US Senate*. USA: United States General Accounting Office 1996.

14 Krieger N, Rehkopf DH, Chen JT*, et al.* The Fall and Rise of US Inequities in Premature Mortality: 1960–2002. *PLoS Med* 2008;**5**:e46.

15 Aragon TJ, Lichtensztajn DY, Katcher BS*, et al.* Calculating expected years of life lost for assessing local ethnic disparities in causes of premature death. *BMC public health* 2008;**8**:116.

16 Cheng ER, Kindig DA. Disparities in Premature Mortality Between High- and Low-Income US Counties. *Prev Chronic Dis* 2012;**9**.

17 K Srinath Reddy BS, Cherian Varghese, and Anbumani Ramadoss. Responding to the threat of chronic diseases in India. *Lancet* 2005;**366**:1744-9.
18 Srivastava A, Mohanty SK. Age and sex pattern of cardiovascular mortality, hospitalisation and associated cost in India. *PloS one* 2013;**8**:e62134.
19 JS Thakur SP, Charu C. Garg, Shanthi Mendis and Nata Menabde. Social and Economic Implications of Noncommunicable diseases in India. *Indian Journal of Community Medicine* 2011;**36(Suppl1)**:13-22.
20 RGI. SRS Based Abridged Life Tables 2003-07 to 2006-10 In: General R, ed. *SRS Analytical Studies*. New Delhi: Registrar General & Census Commissioner 2012.
21 RGI. Report on Cause of Death in India 2001-2003. Office of the Registrar General of India 2009.
22 Census. Census of India 2011. New Delhi: Registrar General & Census Commissioner. 2011.
23 Census. Census of India 2001. New Delhi: Registrar General & Census Commissioner. 2001.
24 Census. Census of India 1991. New Delhi: Registrar General & Census Commissioner. 1991.
25 RGI. Sample Registration System Statistical Report (for the year 1991-2011). New Delhi: Office of The Registrar General, Ministry of Home Affairs, Government of India

Figure 1: YPLL (in million) for top nine causes of death among adult by sex, India, 2002

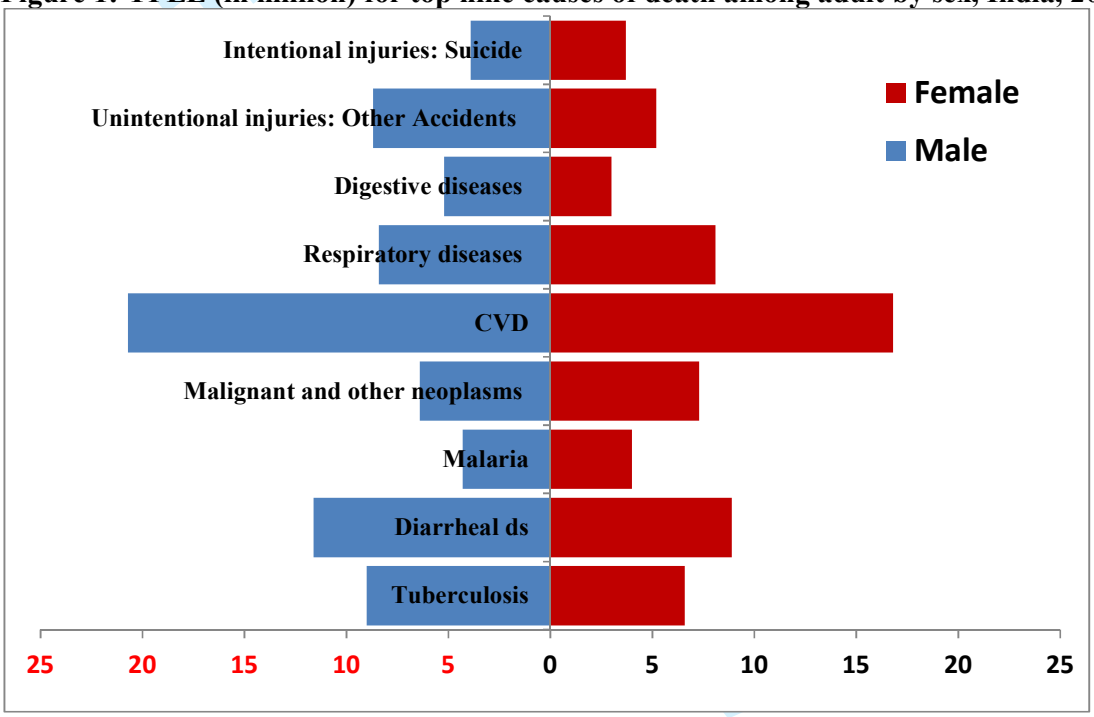


Figure 2: PYPLL (in million) for top nine causes of death among adult by sex, India, 2002

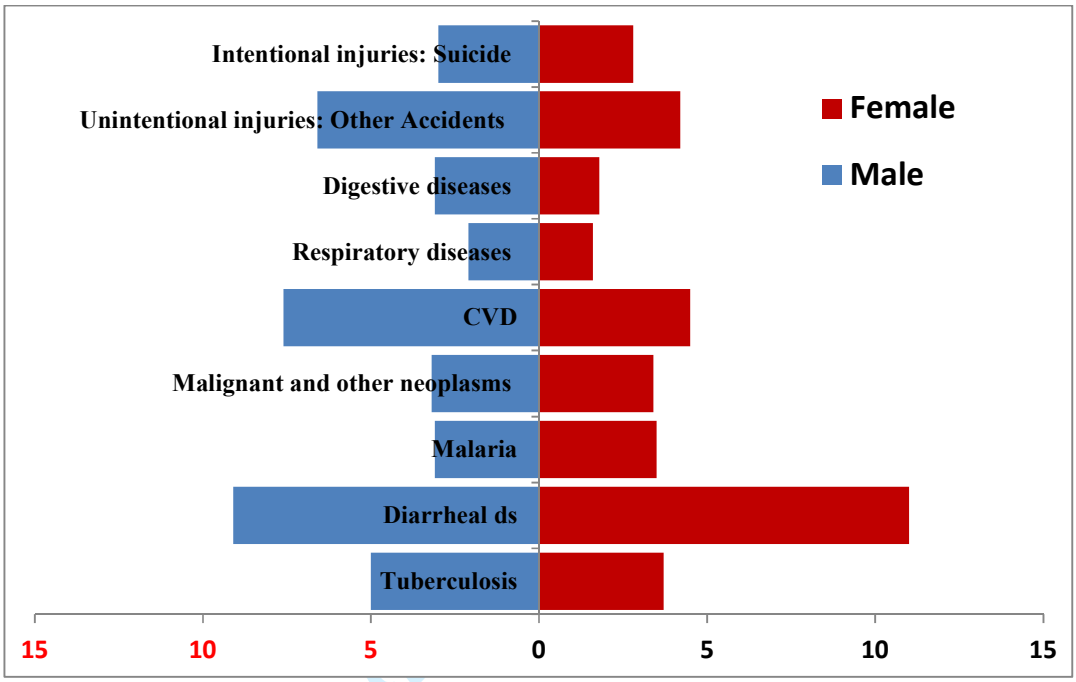


Figure 3: WYPLL (in million) for top nine causes of death among adults by sex, India, 2002

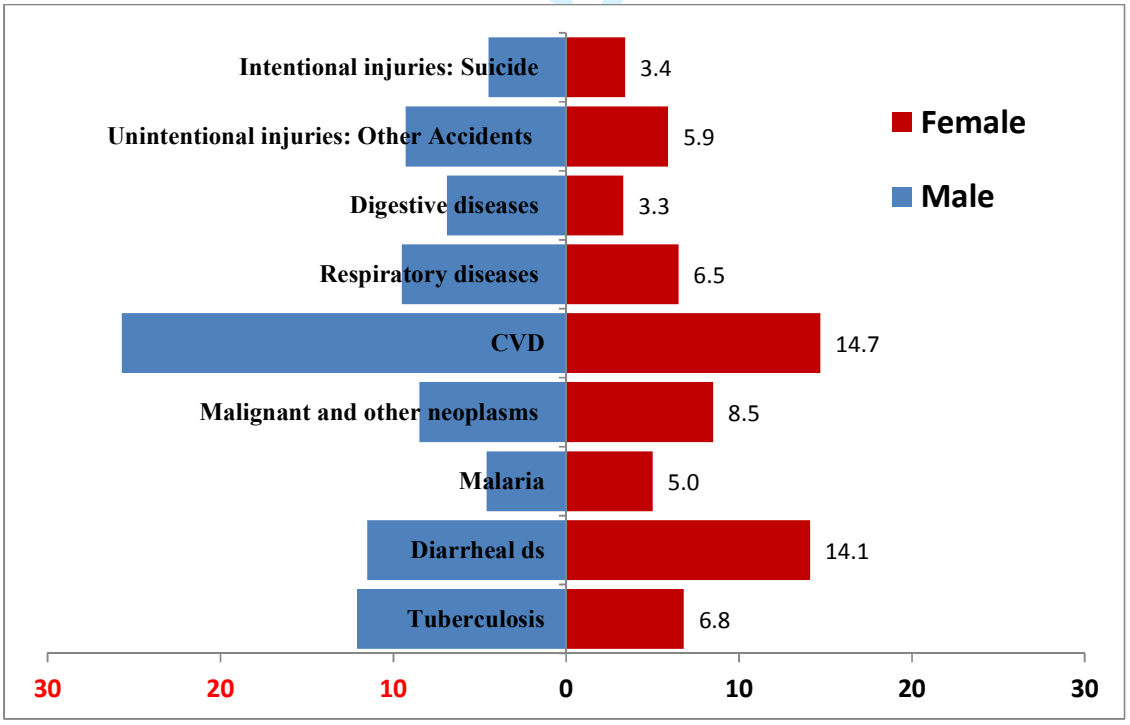


Figure 4:StandardisedWYPLL due to top three diseases by age, Male, India, 2002

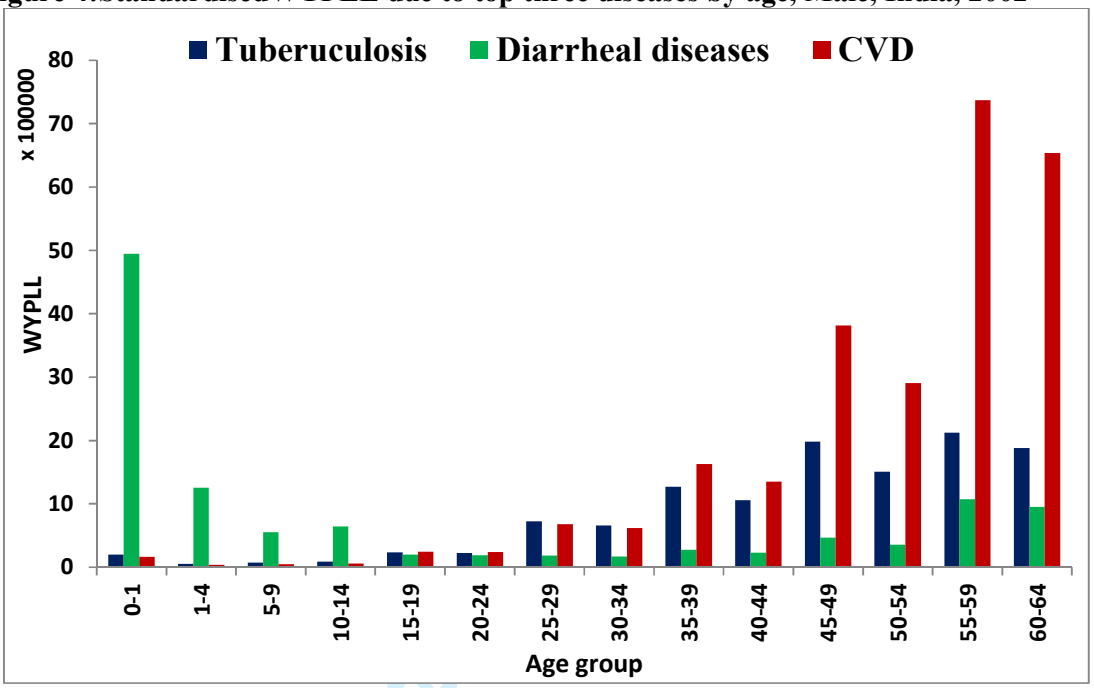
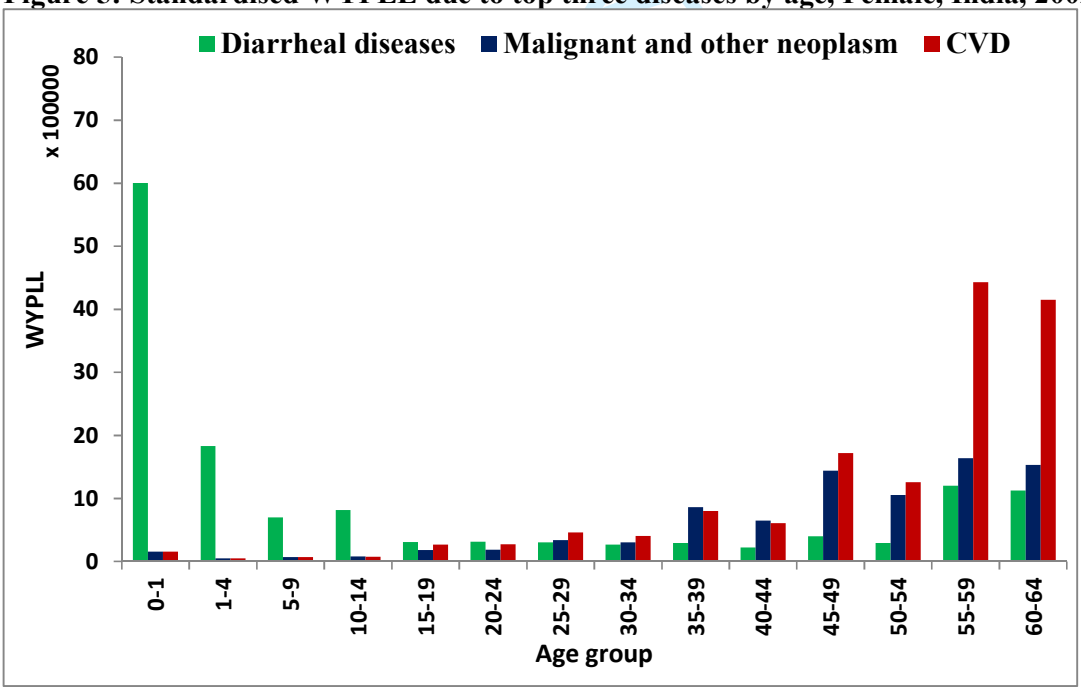


Figure 5: Standardised WYPLL due to top three diseases by age, Female, India, 2002



Research Checklist

1. Title
2. Abstract
   - Background
   - Methods
   - Results
   - Conclusion
3. Strengths and limitation of the studies
4. Introduction
5. Data
   - Ethical issue
   - Census of India
   - Sample Registration System (SRS)
   - Report on Causes of death, 2001-03
6. Methodology
   - Years of potential life lost (PYLL) and its standardization
   - Premature years of potential life lost (PYPLL) and its standardization
   - Working years of potential life lost (WYPLL) and its standardization
7. Results
   - Indices of premature mortality, 1991-2011: YPLL, PYPLL and WYPLL
   - YPLL, PYPLL and WYPLL by causes of death
   - Output in tabular form
8. Conclusion
9. Summary box
   - What is already known on this subject?
   - What does this study add?
10. Author's contribution
11. References
12. Figures

BMJ Open

Age and sex pattern of premature mortality in India

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2014-005386.R1
Article Type:	Research
Date Submitted by the Author:	28-Jun-2014
Complete List of Authors:	Dubey, Manisha; International Institute for Population Sciences , MOHANTY, SANAJY; International Institute for Population Sciences, Department of Fertility Studies
Primary Subject Heading:	Public health
Secondary Subject Heading:	Public health, Research methods, Health policy, Health informatics
Keywords:	Public health < INFECTIOUS DISEASES, Coronary heart disease < CARDIOLOGY, PUBLIC HEALTH, Demography < TROPICAL MEDICINE

Title: Age and sex pattern of premature mortality in India

Author: Manisha Dubey[1] and Sanjay K Mohanty[2]

Corresponding author:
Manisha Dubey, International Institute for Population Sciences (IIPS), Govandi Station Road, Deonar, Mumbai-400088, India; Mobil-9757224808, Email: manikvdlw@gmail.com

Institutional Affiliation:
[1]Research Scholar, International Institute for Population Sciences, Govandi Station Road, Deonar, Mumbai-400088, India; Mobil-9757224808, Email: manikvdlw@gmail.com, manisha.iips@gmail.com
[2]Professor, Department of Fertility Studies, International Institute for Population Sciences, Govandi Station Road, Deonar, Mumbai-400088, India; Mobil-9969687529, Email: sanjayiips@yahoo.co.in, sanjay@iips.net

Word count: 4044

Abstract

Objectives: To estimate the premature mortality by age, sex and cause of death in India.

Setting: Studies on premature mortality are limited in India. Though evidences suggest reduction in infant and child mortality little is known on age and sex pattern of premature mortality in India.

Participants: Based on secondary data from Sample Registration System and Million Death Study.

Primary and secondary outcome measures: : Standardised years of potential life lost (YPLL), premature years of potential life lost (PYPLL) and working years of potential life lost (WYPLL) for broad age groups and by selected causes of death.

Results: During 1991-2011, the age-standardized rate of YPLL (per 1000 population) had declined from 310 to 235 for males and from 307 to 206 for females. The estimated YPLL (in million) had declined from 134 to 147 for males and from 123 to 108 for females. The YPLL for adult (aged 15-65) has increased by 32% for males and 28% for females during the same time. The standardized PYPLL (per 1000 population) has declined from 259 to 137 for males and from 258 to 115 for females. The estimated PYPLL for adult males has increased by 13% and by 32% in 30-45 age group. The standardized rate of WYPLL has declined from 274 to 131 for males and from 295 to 901 for females. The age pattern of these indices suggests significant improvement in early childhood mortality and increasing trends for adult males for 30-45 age group. The standardised rate of YPLL and WYPLL for males and females was highest for cardiovascular disease.

Conclusion: The increasing share of premature deaths among adults and high level of premature mortality suggest continuation of National Rural Health Mission (NRHM) and increasing programmatic attention on prevention and treatment of non-communicable diseases to save premature deaths in India.

Keywords: Premature mortality, YPLL, PYPLL, WYPLL, Causes of death

Strengths and limitations of this study:

This is the first ever study that provides the trends in standardised estimates of premature mortality (YPLL, PYPLL and WYPL) by age and sex in India. It also estimated the standardised indices by cause of death. However, the study could not analyse the trends and pattern in cause specific estimates for the states of India due to unavailability of reliable data over time.

Age and sex pattern of premature mortality in India

Introduction

Premature mortality by age 60 accounts one-third of the total deaths in low and middle income countries in 2008 [1]. While the share of under-five mortality in premature mortality remained high in selected countries, the share of adult mortality is on the rise. The higher level of premature mortality is the mainly due to the demographic and epidemiological transition that has altered the level of mortality and disease pattern across the age groups [2, 3]. The Non-communicable Diseases (NCDs) are the leading cause of death and primarily affecting the working age group [4, 5]. Studies suggest that premature deaths and hospitalisation adversely affect economic growth and development [6-8]. The estimated loss of GDP in 2004 due to Cardiovascular Disease (CVD) alone was about `one trillion in India[8].

The concept of premature mortality was evolved to measure the increasing social and economic cost of mortality at younger age because the conventional measure such as crude death rate and age specific death rate does not quantify the extent of life years lost at early ages[9].The premature mortality is the best single proxy measure for reflecting differences in the health status of the populations [10].A number of measures was developed and used to quantify the extent of premature mortality; potential years of the life lost (PYLL), premature years of potential life lost (PYPLL), the working years of potential life lost (WYPLL) and the valued years of potential life lost (VYPLL). Each of the method is a function of age at death and the number of deaths at that age [11]but vary with respect to weight and upper and lower limit of the age. Though many new indices have been developed to measure the premature mortality like DALY (Disability adjusted life years), HALY (Health adjusted life years), YLL (Years of life lost) etc., these are based on a number of assumptions and data

limitations. On the other hand, the YPLL, PYPLL and WYPLL capture the premature mortality as it is based on fewer assumptions and data input.

The potential years of life lost (PYLL) is the most commonly used indicator to quantify premature mortality. A large number of studies estimated the PYLL to rank the cause of death and understand level, pattern and differentials in mortality by income, gender, ethnic groups and regions. Ranking of the major cause of premature mortality using PYLL revealed that accidents (38.66%) accounts for largest PYLL followed by circulatory system (24.85%) and Neoplasms (15.67%) in Canada [12]. The PYLL varies largely among OECD countries and by sex. Among the females, the estimated PYLL (per 1000) was highest in Russian Federation (7.1) and lowest in Iceland (1.5). Among males, the PYLL was 20.2 in Russia and 3.0 in Iceland [13]. Using mortality data over four decades, studies found absolute and relative decline in premature mortality across socio-economic and racial/ethnic group during the early period (1966-80) and widening relative health inequalities in the subsequent period (1980-2002) [14]. The large health disparities between African American and other ethnic groups in San Francisco were estimated using expected years of life lost. With respect to gender, the estimated years of life lost among males were73,627 and 51,194 among females. The leading causes of premature deaths were HIV/AIDS followed by suicide and drug over dose among males and lung cancer, breast cancer and hypertensive heart diseases among females [15]. Studies also suggest that the association between income and premature mortality (deaths before age 75) was stronger among low-income counties compared to high-income counties. Among carious income group, the premature mortality varies by geographic, socio-demographic, racial/ethnic and behavioural factors [15].

Like other developing countries, India is also experiencing rapid demographic and epidemiological transition. While the total fertility rate is close to replacement level, the life

expectancy has reached 64.6years for male and 67.7 years for female by 2008 [16]. There has been a significant reduction in under-five deaths in last decade from 2.5 million in 2001 to 1.5 million in 2012[17, 18] During 1991 and 2011, the share of under-five deaths to total deaths has declined from 35% to 17% while that of adult deaths (deaths in 15-59 years) has increased from 27%to 30%[19].On the other hand, the NCDs are the leading cause of mortality and morbidity in India. The non-communicable diseases (NCDs) account for 62% of the total burden of foregone DALYs and 53% of total deaths in India[20].The cardiovascular deaths (CVDs) was estimated at1.4 million (56.2% in 25-69 age group) in 2004 and projected at 2.1 million (45% in 25-69 age group) by 2021[21].The hospitalisation rate and outpatient visit due to NCDs rose from 32% to 40% and 22% to 35%, respectively, during 1995 to 2004[20].The CVDs accounted loss of 9.2 million productive life among 35-64 years age group in 2000 and projected at 17.9 million by 2030 [22]. Though a large number studies has been carried out on trends, differentials and determinant of mortality, there is no study that examined the premature mortality in India [23-26]. In this context it is necessary to understand the extent of avoidable deaths in India.

The aim of this paper is to examine the age and sex pattern of premature mortality in India over last two decades (1991-2011). It also estimates the extent of premature mortality by selected causes of death for 2002. The paper has been conceptualised with the following rationale. First, evidences suggest increase in adult mortality in India, which are premature and avoidable. The social, psychological and economic costs associated with premature deaths are devastating. Hence prevention of these deaths must be a public health priority. Second, the NCDs are the leading cause of death, and the onset of NCDs is 10-15 years earlier than that of developed countries. These deaths are primarily affecting the working age group which results into rise in premature mortality. On the other hand, the public health

centres are not equipped enough to treat the NCDs. Third, though the premature mortality has been extensively studies in developed countries, there is no study that has estimated the level and trend of premature mortality in India. The quantification of premature mortality helps to identify the social and economic cost associated with mortality, ranks the disease burden and has greater policy relevance. In this context, this paper provides the numerical estimates on the premature deaths in India over time and by causes of death for broad age group.

Data and methods

This paper uses data from multiple sources; the census of India, 1991, 2001 and 2011, the sample registration system (SRS), 1991-2011 and report on cause of death, 2001-03 [27-31]. We have used published data and it does not involve any ethical issues. The Indian census is the largest single source of information on demographic and selected socio-economic characteristics of the population. We have used the age and sex distribution of the population for 1991, 2001 and 2011 and the age-sex distribution of intercensal periods (1996 and 2006) from SRS. Data on causes of death is extremely useful for planning of health programmes and for intervention strategies. The special survey of deaths (SSD) was jointly undertaken by the Office of the Registrar General, India (ORGI)and the Centre for Global Health Research (CGHR) [27] in 2004-05. The SSD was implemented during 2004-05 covering 0.114 million deaths from 1.1 million households, which have been recorded during2001-2003 in Sample Registration System (SRS)[27]. The cause of death was determined using an advanced form of Verbal Autopsy called the “RHIME” or Representative, Re-sampled, Routine Household Interview of Mortality with Medical Evaluation method. We have used data on the distribution of deaths by age, sex and cause from this report to estimate the premature mortality. We may mention that, besides these sources, the vital registration system and the Medical Certification of Cause of Deaths (MCCD) provide the deaths by age, sex and

selected characteristics, However, the vital registration system in India is incomplete and have limited used for analyses[32]. The MCCD also have very low coverage and it is not suitable for a representative analysis[33]. .

This paper use three indices, namely, the YPLL, PYPLL and WYPL and .the standardised rates to understand the extent of premature mortality in India. In case of standardised rates, the age distribution of Kerala, 2011 is used as the reference population because the Kerala is demographically advanced state of India. The three year moving average of the ASDR is used. Age group 15-65 years is referred as adult age. The analysis has been carried out for India. The method of computing each of the indices is given below:

a. Years of Potential Life Lost (YPLL)

The YPLL is a summary measure of premature mortality that gives higher weight to deaths occurring at younger age and lower weight to the deaths at higher ages. It estimates the average years a person would have lived had he or she not died prematurely[11].The method used in this study is given by:

$$\boldsymbol{YPLL = \sum_{i=0}^{\infty} d_i * L_i} \qquad \textbf{(1)}$$

where L_i is the life expectancy at age i, d_i is the number of deaths at age i.
The deaths are weighted by life expectancy at each age.

The standardised YPLL and corresponding rates have been calculated as follows[12]:

$$\textbf{Standardized YPLL} = \boldsymbol{YPLL} * \left(\frac{\boldsymbol{P_{i,r}}}{\boldsymbol{N_r}}\right) * \left(\frac{\boldsymbol{N}}{\boldsymbol{P_i}}\right) \qquad \textbf{(2)}$$

Where $\boldsymbol{P_{i,r}}$ is population in the $\boldsymbol{i}^{th}$ age group in the reference population (Kerala);
$\boldsymbol{N_r}$ is the total reference population (Kerala)
$\boldsymbol{N}$ is the total study population;
$\boldsymbol{P_i}$ is the population in the $\boldsymbol{i}^{th}$ age group in the study population.

Rate of YPLL= $\frac{\sum YPLL}{N} * 1000$ **(3)**

b. Premature years of potential life lost (PYPLL)

The PYPLL measures the loss of years of productive life due to death before a cut-off age. The upper age limit on estimating PYLL varies by countries and authors[11]. We have used the upper age limit of 65 years, close to the average longevity in India

$$PYPLL = \sum_{i=0}^{U} d_i * (U - i) \quad \textbf{(4)}$$

where d_i is the number of deaths at age i,

U is the upper limit of age (65 years).

In each age, the deaths are weighted by difference in upper age limit and age at death.

Standardized PYPLL = $PYPLL * \left(\frac{P_{i,r}}{N_r}\right) * \left(\frac{N}{P_i}\right)$ **(5)**

where $P_{i,r}$ is the population in the i^{th} age group in the reference population (taken as Kerala);

N_r is the total reference population in age group 0 to 65 (taken as Kerala);

N is the total study population in age group 0-65;

P_i is the population in the i^{th} age group in the study population.

Rate of PYPLL= $\frac{\sum PYPLL}{N} * 1000$ **(6)**

where N is the total population in age group 0 to 65.

c. Working years of potential life lost (WYPLL)

The WYPLL measures the working life years lost during "the working age period" in a population.

$$WYPLL = \sum_{i=0}^{W-1} d_i * (U - W) + \sum_{i=W}^{N} d_i * (U - i) \quad \textbf{(7)}$$

where d_i is the number of deaths at age i,

U is the upper cut off age (65 years);

W is the lower cut-off age (14 years).

Here a constant weight is assigned to the deaths before age 14 years; difference in upper and lower age cut-off and deaths at age 14 and above are weighted by difference between upper age limit and age at death.

$$\textbf{Standardized WYPLL} = \boldsymbol{WYPLL} * \left(\frac{P_{i,r}}{N_r}\right) * \left(\frac{N}{P_i}\right) \quad \textbf{(8)}$$

where $P_{i,r}$ is population in the i^{th} age group in the reference population (taken as Kerala);

$N_r$is the total reference population in age group 0 to 65 (taken as Kerala);

$N$is the total study population in the age group 0 to 65;

P_i is the population in the i^{th} age group in the study population.

$$\textbf{Rate of WYPLL}=\frac{\sum \boldsymbol{WYPLL}}{\boldsymbol{N}} * 1000 \quad \textbf{(9)}$$

where N is the total study population in the age group 0 to 65 years.

The estimated population and deaths by age and sex over 1991-2011 is shown in Appendix 1 and 2.

Cause specific indices of premature mortality

We have also computed the YPLL, PYPLL and WYPLL for selected causes of death using the similar methods and weighting procedure for 2002. The distribution of deaths by cause, age and sex and taken from Report on Causes of Death, RGI, 2001-03. The weight assigned for each age group is inbuilt in the each of the indices. In general, in each of the method, the younger age groups get a higher weight age and the older age group gets a lower weight.

Results

Results are presented in two sections. Section 1 describes the trend of premature mortality by age and sex and section 2 describe the estimated years of premature deaths by causes of death.

Section 1: Trends in premature mortality by age and sex, 1991-2011

Table 1 presents the standardized YPLL in millions for a period of two decades (1991-2011) by broad age group and sex. During 1991-2011, the YPLL has increased from 134million to 147 million among males while it has declined from 123 million to 108 million among female. The rate of YPLL has declined from 310 to 235 per 1000 population for males and from 307 to 206 for females in the same period. Though the overall decline in YPLL reflects the marked improvement in mortality in the population, it conceals large discrepancies in broad age group. The decline in YPLL was significant among younger age group, particularly among children while it has increased among adults (15-64 years). Among children under five years of age, the YPLL has declined by 38% for male and 32% for females in the same period. Among adults (in 15-64 age groups), the YPLL has increased for males in most of the age group. For example during 1991-2011, the YPLL for males in 30-45 age group has increased by 48% and for 45-59 it has increased by 25%. Among adult females, the largest decline in YPLL was in the age group 5-14 and increased in the age group 60-70. Though the absolute value of YPLL has increased during 1991-2011, the rate of YPLL has declined. Though the YPLL has declined largely for 0-4 year, it remains highest in this age group. The YPLL has not shown secular decline; had initially increased during 1991-2001 and declined thereafter.

Table 1: Trends in years of potential life lost (YPLL) in million (standardised) by age and sex and rate of YPLL (per 1000 population) in India, 1991-2011

Age group	1991		1996		2001		2006		2011		Percentage reduction (1991-2011)	
YPLL in million	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
0-4	56.3	53.1	50.2	48.0	62.3	60.4	45.0	41.5	35.0	36.3	37.8	31.6
5-14	7.8	7.9	7.9	8.3	7.3	7.0	7.2	6.8	5.6	5.0	28.2	36.7
15-29	10.9	13.2	11.3	13.0	13.1	14.7	13.1	12.9	12.2	11.2	-11.9	15.2
30-45	12.6	11.9	14.4	12.5	17.4	13.6	18.2	12.5	18.7	10.6	-48.4	10.9
45-59	22.5	14.9	24.6	17.2	28.1	18.7	26.5	16.7	28.2	16.9	-25.3	-13.4
60-70	13.4	10.8	17.1	13.5	18.4	14.6	18.6	15.0	20.0	15.1	-49.3	-39.8
70+	10.5	11.5	20.2	23.0	18.4	12.4	23.8	50.5	26.8	30.7	-155.2	-167.0
0-14	64.1	60.9	58.1	56.2	69.5	67.4	52.2	48.3	40.7	15.1	36.5	75.2
15-65	52.7	45.1	59.9	49.8	67.7	53.8	68.1	49.9	69.6	57.8	-32.1	-28.2
Total	**134.1**	**123.2**	**145.7**	**135.3**	**165**	**141.3**	**152.5**	**155.8**	**146.6**	**107.9**	**-9.3**	**12.4**
YPLL Rate	310.0	306.9	302.8	302.4	311.0	285.4	264.6	288.8	235.2	206.0	24.1	32.9

Table 2 provides the premature years of potential life lost (PYPLL) by age and sex in last two decades. The PYP LL fixes an upper limit to which individual are expected to survive and measures the loss of years of productive life due to death before a selected cut-off age. During 1991-2011, the estimated PYPLL for male has declined from 108 to 81 million while that of females has declined from 99 to 64 million. The rate of PYPLL among males has declined from 259 in 1991 to 224 in 2001 and further to 137 by 2011. Among females, the rate of PYPLL has declined from 258 in 1991 to 213 in 2001 and 115 in 2011. The decline in PYPLL is faster among females compared to males. During 1991-2011, the YPLL among children under five years of age has declined from 64 million years to 35 million years for male and from 60 million to 34 million years for females. The decline was secular for both male and females. On the other hand, in age group (15-65), the PYPLL has declined for females but not for males. The PYPLL for males in the age group 30-45 has increased from 11 million years to 14 million years. In all the years studied, the PYPLL among males was highest in 0-4 age group followed by age group 45-59 years. Similarly for females the PYPLL was highest in 0-4 age group followed by 15-29 age group. The PYPLL was

increased by 13% among adult males and declined by 20% among adult females. The increase in PYPLL among males was highest in the age group 30-45 (32%) followed by 60-65. While declining in PYPLL among children is a good sign, the increase in these indices among adult in the prime working age group is a concern. This is possibly due to increase in non-communicable diseases that are largely affecting the prime working age groups.

Table 2: Trends in premature years of potential life lost (PYPLL) in million (standardised) by age and sex and rate of PYPLL (per 1000 population) in India, 1991-2011

Age group	1991		1996		2001		2006		2011		Percentage reduction (1991-2011)	
PYPLL in million	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
0-4	63.8	60.1	54.0	51.2	65.5	61.9	46.1	41.1	34.9	34.5	45.3	42.6
5-14	7.8	7.7	7.5	7.7	6.7	6.4	6.7	6.0	5.1	4.3	34.6	44.2
15-29	10.4	12.2	10.2	11.3	11.7	12.3	11.5	10.7	10.5	9.0	-1.0	26.2
30-45	10.8	9.6	11.6	9.4	13.6	9.9	14.0	8.9	14.2	7.3	-31.5	24.0
45-59	13.6	8.5	13.4	8.7	14.5	8.8	13.7	7.8	14.4	7.6	-5.9	10.6
60-65	1.3	0.9	1.6	1.1	1.4	1.0	1.6	1.1	1.6	1.0	-23.1	-11.1
0-14	71.6	67.8	61.5	58.9	72.2	68.3	52.8	47.1	40.0	38.8	44.1	42.8
15-65	36.1	31.2	36.8	30.5	41.2	32.0	40.8	28.5	40.7	24.9	-12.7	20.2
Total	**107.7**	**99.1**	**98.3**	**89.4**	**113.6**	**100.1**	**93.6**	**75.5**	**80.9**	**63.8**	**24.9**	**35.6**
WYPLL Rate	**259.4**	**257.6**	**212.6**	**208.8**	**224.2**	**212.9**	**170.0**	**147.0**	**136.9**	**115.2**	47.2	55.3

Table 3 presents the working years of potential life lost (WYPLL) by age and sex for last two decades. The WYPLL gives a higher weightage to working age population. During 1991-2011, the WYPLL has declined from 114 million to 77 million among males and from 113 million to 45 million among females. The rate of WYPLL has declined from 274 in 1991 to 131 per 100 for males. Among females, the rate of WYPLL has declined from 295 in 1991 to 91 in 2011. The estimate of WYPLL by age over time shows a similar pattern as that of YPLL. Among females, the WYPLL has declined over all age group while for males it has declined only for younger age group. Among males aged 30-45 years, the WYPLL has increased from 9 million years in 1991 to 13 million years by 2011. The WYPLL was higher among females compared to males at all age group. The standardisation of WYPLL does not change the gradient across age and sex over a period of time but level has changed.

Table 3: Trends in working years of potential life lost (WYPLL) in million (standardised) by age and sex and rate of WYPLL (per 1000 population) in India, 1991-2011

Age group	1991		1996		2001		2006		2011		Percentage reduction (1991-2011)	
WYPLL in million	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
0-4	73.4	76.9	61.3	63.0	72.3	74.8	47.9	46.0	34.0	36.4	53.7	52.7
5-14	10.3	11.4	9.8	10.9	8.7	8.9	8.0	7.8	5.7	5.3	44.7	53.5
15-29	8.7	10.0	8.5	9.3	10.0	10.2	10.2	9.3	9.7	8.1	-11.5	19.0
30-45	9.0	7.7	9.7	7.8	11.6	8.3	12.4	7.7	13.1	6.5	-45.6	15.6
45-59	11.4	6.8	11.3	7.1	12.4	7.2	12.2	6.8	13.2	6.8	-15.8	0.0
60-65	1.1	0.8	1.4	0.9	1.2	0.8	1.4	1.0	1.5	0.9	-36.4	-12.5
0-14	83.7	88.3	71.1	73.9	81.0	83.7	55.9	53.8	39.7	41.7	52.6	52.8
15-65	30.2	25.3	30.9	25.1	35.2	26.5	36.2	24.8	37.5	22.3	-24.2	11.9
Total	**113.8**	**113.0**	**102.2**	**99.0**	**116.3**	**110.0**	**92.1**	**78.0**	**77.2**	**45.0**	**32.2**	**60.2**
WYPLL Rate	**274.2**	**294.8**	**220.9**	**231.5**	**229.6**	**234.3**	**167.3**	**152.8**	**130.7**	**90.6**	52.3	69.3

Section 2: Premature mortality by causes of death

Table 4 and figure 1, 2 and 3 presents the indices of premature mortality by causes of death for male and female. We have taken top nine causes of death among adults and computed YPLL, PYPLL and WYPLL. These indices were estimated for the year 2002 because the causes of death data were available only for this period. Among the nine leading causes of death, the CVD account for maximum loss in YPLL and WYPLL. The WYPLL among males was 26 million due to CVDs, 12 million due to Tuberculosis and 11 million due to Diarrheal diseases. The rate of WYPLL among males was also maximum for CVDs (50) followed by Tuberculosis (23) and diarrheal diseases (22). Similarly, for females, the WYPLL was highest for CVDs (15 million) followed by Diarrheal diseases (14) and malignant and other neoplasms (8). Among males, the YPLL was highest for CVDs (21) followed by diarrheal diseases (12) and Tuberculosis (9). For females, the YPLL was highest for CVDs (17) followed by diarrheal diseases (9) and Respiratory diseases (8). In terms of PYPLL, among males, the PYPL rate was highest for diarrheal diseases (9) followed by CVDs (8) and accidents (7). In the case of females also, the rate of PYPLL was highest due to diarrheal diseases (11) followed by CVD (4) and accidents (4). The corresponding rate of the YPLL, PYPLL and WYPLL shows the same trend for the given causes of deaths.

Table 4: Estimates of YPLL, PYPLL and WYPLL and the corresponding rates by cause in India,2002

Causes of death	Rate (per 1000 population)						Absolute number (million)					
	YPLL		PYPLL		WYPLL		YPLL		PYPLL		WYPLL	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Tuberculosis	16.7	13.0	9.7	7.7	23.3	14.2	9.0	6.6	5.0	3.7	12.1	6.8
Diarrheal diseases	21.4	17.6	17.6	23.0	22.2	29.4	11.6	8.9	9.1	11.0	11.5	14.1
Malaria	7.9	7.8	5.9	7.2	8.8	10.4	4.3	4.0	3.1	3.5	4.6	5.0
Malignant and other neoplasms	11.9	14.6	6.2	7.1	16.4	17.8	6.4	7.3	3.2	3.4	8.5	8.5
CVD	38.2	33.3	14.6	9.5	49.6	30.7	20.7	16.8	7.6	4.5	25.7	14.7
Respiratory diseases	15.5	16.0	4.0	3.3	18.3	13.5	8.4	8.1	2.1	1.6	9.5	6.5
Digestive diseases	9.7	5.9	5.9	3.8	13.2	6.9	5.2	3.0	3.1	1.8	6.9	3.3
Unintentional injuries: Other Accidents	16.1	10.4	12.7	8.8	17.9	12.3	8.7	5.2	6.6	4.2	9.3	5.9
Intentional injuries: Suicide	7.3	7.3	5.8	5.8	8.6	7.1	3.9	3.7	3.0	2.8	4.5	3.4

Figure 4 and 5 depicts the age pattern of WYPLL for top three causes of death among male and female respectively. The Diarrheal diseases accounts for the majority of the years lost among children (0-14 years) whereas CVD accounts for the highest life years lost among adults and old population. The adult population is affected by both communicable and non-communicable diseases. For example, among males, CVD and Tuberculosis are high in adult ages. Similarly, among adult females, CVD and Malignant and other neoplasms are leading causes of premature mortality.

Discussion and Conclusion

The concept of premature mortality has been used as an important measure of health status and a guide for health policies of many developed countries. Estimates of premature mortality and understanding the factors affecting premature mortality are prerequisite in reducing avoidable mortality and improving the health of the population and. In last two decade, India has made significant progression in reduction of infant and child mortality and improvement in longevity. The increase in this health outcome is evident across socio-economic groups and space. A number of studies have helped in understanding the differentials, determinants and

inequality in infant and child mortality in India [17, 34-36]. However, evidences suggest increasing adult mortality and there are limited studies that covered the premature mortality in India. In this context, we have attempted to provide the numerical estimates on premature mortality using a set of indices by age and sex over two decades. We have used the published data from SRS, special survey on cause of death and estimated the YPLL, PYPLL and WYPLL for broad age groups. Though the estimates on premature mortality by cause of death are 13 years old, the inferences will not change because of increasing NCDs. The following are the salient findings.

First, we found a decline in premature mortality indices (YPLL, PYPLL and WYPLL) and their rates for both male and female except YPLL for males. This is consistent with the overall improvement in health situation of the population. Second, the decline in premature mortality indices conceals large differential across the age group and sex. While the decline in premature mortality indices is largely due to improvement in mortality in the younger age group e.g. 0-14 years, it has indeed increased among male adults. Third, the age pattern of the indices reveals that the premature mortality continued to be highest in 0-4 age group though the decline was highest in the same age group; declined by more than one-third in last two decades. However, all these indices have increased in 35-49 age group suggesting increasing in adult male mortality. Fourth, the YPLL and WYPLL were highest due to CVDs for both male and female. Most of the CVD deaths are premature and affecting the prime working age groups. Fifth the estimate of PYPLL was highest for Diarrheal diseases followed by CVDs. This is because the PYPLL gives a higher weightage to children and the Diarrheal diseases are higher among children.

From the above findings, it is clear that the level of premature mortality in India is higher than many developing and developed countries. The level of premature mortality is high not only because of higher under-five mortality but also due to higher adult mortality. While the existing programme in reduction of under-five mortality should continue, the programme needs to be intensified for reduction of adult mortality. Reduction in adult mortality can be achieved by increasing budgetary spending for NCDS of central and state government that would help to intensify efforts on prevention and management of NCDs. Large scale investment on medical infrastructure for NCDs and increase coverage of health insurance will be helpful in this direction. The policies to reduce production and consumption of alcohol and tobacco and creating awareness on healthy life style can reduce the risk factors of NCDs and avoidable mortality. The programme on NCDs by central government are in place and the twelfth five year plan made specific provision for management and control of NCDs under three categories; programmes for life style chronic diseases and risk factor, programmes for disability prevention and rehabilitation and health promotion and prevention of NCDs[37]. The continuation of maternal and child health programme and effective implementation of non-communicable diseases can reduce avoidable mortality in India.

Summary box

What is already known on this Subject?

In last two decades, along with socio-economic development, India has made significant improvement in health outcome. While the life expectancy at birth has increased, the infant mortality rate and child mortality rate has declined across socio-economic groups. The diseases pattern is changing fast and the non-communicable diseases are the leading cause of death in India. The premature mortality is resultant of low child survival and increasing NCDs in India.

What does this study add?

This study adds to the available literature on premature mortality by providing the standardised estimates of premature mortality by age and sex in India over two decades. It also suggests that the premature mortality is on rise among men in prime working age group. The cardiovascular disease is the leading cause of premature mortality followed by diarrheal diseases.

Author's Contribution: MD and SKM conceptualised the paper, prepared analytical plan and drafted the paper.

Conflict of Interest: None

Funding and Ethical Issues: It is an independent research and did not receive any funding.

Data Sharing: No additional data available

References

1 WHO. Premature NCD deaths: Situation and trends. Geneva: World Health Organisation 2014.

2 Joshi R, Cardona M, Iyengar S, *et al.* Chronic diseases now a leading cause of death in rural India--mortality data from the Andhra Pradesh Rural Health Initiative. *International journal of epidemiology* 2006;**35**:1522-9.

3 Quigley MA. Commentary: shifting burden of disease--epidemiological transition in India. *International journal of epidemiology* 2006;**35**:1530-1.

4 Upadhyay RP. An overview of the burden of non-communicable diseases in India. *Iranian journal of public health* 2012;**41**:1-8.

5 Goyal A, Yusuf S. The burden of cardiovascular disease in the Indian subcontinent. *The Indian journal of medical research* 2006;**124**:235-44.

6 Bloom DE, Canning D. Health and Economic Growth: Reconciling the Micro and Macro Evidence. *CDDRL WORKING PAPERS*. Stanford: Stanford University 2005.

7 Bloom DE, Canning D, Sevilla J. The Effect of Health on Economic Growth: A Production Function Approach. *World Development* 2004;**32**:1-13.

8 Mahal A. The poor and health service use in India. *Health, Nutrition and Population (HNP) Discussion Paper*. The World Bank: Washington, DC 2001.

9 Dempsey M. Decline in tuberculosis: the death rate fails to tell the entire story. *Am Rev Tuberculosis* 1947;**56**:157-64.

10 Scanlon WJ. A Health Status Indicator for Targeting Federal Aid to States. In: Fastrup J, ed. *Report to the Chairman, Committee on Labor and Human Resources, US Senate*. USA: United States General Accounting Office 1996.

11 Gardner JW, Sanborn JS. Years of potential life lost (YPLL)--what does it measure? *Epidemiology (Cambridge, Mass)* 1990;**1**:322-9.

12 Romeder JM, McWhinnie JR. Potential years of life lost between ages 1 and 70: an indicator of premature mortality for health planning. *International journal of epidemiology* 1977;**6**:143-51.

13 OECD. Premature mortality. *Health at a Glance 2011: OECD Indicators*. OECD Publishing: Organisation of Economic Cooperation and Development 2011.

14 Krieger N, Rehkopf DH, Chen JT, *et al.* The Fall and Rise of US Inequities in Premature Mortality: 1960–2002. *PLoS Med* 2008;**5**:e46.

15 Cheng ER, Kindig DA. Disparities in Premature Mortality Between High- and Low-Income US Counties. *Prev Chronic Dis* 2012;**9**.

16 RGI. SRS Based Abridged Life Tables 2003-07 to 2006-10 In: General R, ed. *SRS Analytical Studies*. New Delhi: Registrar General & Census Commissioner 2012.

17 Ram U, Jha P, Ram F, *et al.* Neonatal, 1-59 month, and under-5 mortality in 597 Indian districts, 2001 to 2012: estimates from national demographic and mortality surveys. *The Lancet Global Health* 2013;**1**:e219-e26.

18 UN. World Population Prospects: The 2012 Revision. In: Population Division DoEaSA, ed. New York: United Nations 2014.

19 Dubey M. Trends and prospects of adult mortality by cause of death in India. Mumbai: International Institute for Population Sciences 2013:117.

20 JS Thakur SP, Charu C. Garg, Shanthi Mendis et al. Social and Economic Implications of Noncommunicable diseases in India. *Indian Journal of Community Medicine* 2011;**36(Suppl1)**:13-22.

21 Srivastava A, Mohanty SK. Age and sex pattern of cardiovascular mortality, hospitalisation and associated cost in India. *PloS one* 2013;**8**:e62134.
22 K Srinath Reddy BS, Cherian Varghese, et al. Responding to the threat of chronic diseases in India. *Lancet* 2005;**366**:1744-9.
23 Saikia N, Jasilionis D, Ram F*, et al.* Trends and geographic differentials in mortality under age 60 in India. *Population studies* 2011;**65**:73-89.
24 Dubey M. Trends and prospects of adult motality in India. Mumbai: International Institute for Population Sciences 2013:117.
25 Singh A, Ladusingh L. Increasing life expectancy and convergence of age at death in India. *GENUS* 2013;**69**:83-9.
26 Yadav A, Yadav S, Kesarwani R. Decelerating Mortality Rates in Older Ages and its Prospects through Lee-Carter Approach. *PloS one* 2012;**7**:e50941.
27 RGI. Report on Cause of Death in India 2001-2003. Office of the Registrar General of India 2009.
28 Census. Census of India 2011. New Delhi: Registrar General & Census Commissioner. 2011.
29 Census. Census of India 2001. New Delhi: Registrar General & Census Commissioner. 2001.
30 Census. Census of India 1991. New Delhi: Registrar General & Census Commissioner. 1991.
31 RGI. Sample Registration System Statistical Report (for the year 1991-2011). New Delhi: Office of The Registrar General, Ministry of Home Affairs, Government of India
32 India RGo. Vital Statistics of India Based on the Civil Registration System 2010. New Delhi: Office of the Registrar General of India, Ministry of Home Affairs, Government of India 2013.
33 RGI. Report on Medical Certification of Cause of Death, 2010. New Delhi 2014.
34 Mohanty SK. Multidimensional Poverty and Child Survival in India. *PloS one* 2011;**6**:e26857.
35 Saikia N, Singh A, Jasilionis D*, et al.* Explaining the rural-urban gap in infant mortality in India. *Demographic Research* 2013;**29**:473-506.
36 Singh A, Pathak PK, Chauhan RK*, et al.* Infant and Child Mortality in India in the Last Two Decades: A Geospatial Analysis. *PloS one* 2011;**6**:e26856.
37 PlanningCommission. Report of the Working Group on Disease Burden for 12th Five Year Plan. New Delhi: Planning Commission of India, Government of India 2011.

FIGURE LEGENDS

Figure 1: YPLL (in million) for top nine causes of death among adults by sex in India, 2002

Figure 2: PYPLL (in million) for top nine causes of death among adults by sex in India, 2002

Figure 3: WYPLL (in million) for top nine causes of death among adults by sex in India, 2002

Figure 4: Standardised WYPLL by top three diseases and age among males in India, 2002

Figure 5: Standardised WYPLL by top three diseases and age among females in India, 2002

Title: Age and sex pattern of premature mortality in India

Author: Manisha Dubey[1] and Sanjay K Mohanty[2]

Corresponding author:
Manisha Dubey, International Institute for Population Sciences (IIPS), Govandi Station Road, Deonar, Mumbai-400088, India; Mobil-9757224808, Email: manikvdlw@gmail.com

Institutional Affiliation:
[1]-Research Scholar, International Institute for Population Sciences, Govandi Station Road, Deonar, Mumbai-400088, India; Mobil-9757224808, Email: manikvdlw@gmail.com, manisha.iips@gmail.com
[2]Professor, Department of Fertility Studies, International Institute for Population Sciences, Govandi Station Road, Deonar, Mumbai-400088, India; Mobil-9969687529, Email: sanjayiips@yahoo.co.in, sanjay@iips.net

~~**Keywords:** Premature mortality, YPLL, PYPLL, WYPLL, Causes of death~~

Word count: ~~3315~~4044

Formatted: Font: Times New Roman

Abstract

Objectives: To estimate the premature mortality by age, sex and cause of death in India.

Setting: Studies on premature mortality are limited in India. Though evidences suggest reduction in infant and child mortality little is known on age and sex pattern of premature mortality in India.

Participants: Based on secondary data from Sample Registration System and Million Death Study.

Primary and secondary outcome measures: : Standardised years of potential life lost (YPLL), premature years of potential life lost (PYPLL) and working years of potential life lost (WYPLL) for broad age groups and by selected causes of death.

Results: During 1991-2011, the age-standardized rate of YPLL (per 1000 population) had declined from 310 to 235 for males and from 307 to 206 for females. The estimated YPLL (in million) had declined from 134 to 147 for males and from 123 to 108 for females. The YPLL for adult (aged 15-65) has increased by 32% for males and 28% for females during the same time. The standardized PYPLL (per 1000 population) has declined from 259 to 137 for males and from 258 to 115 for females. The estimated PYPLL for adult males has increased by 13% and by 32% in 30-45 age group. The standardized rate of WYPLL has declined from 274 to 131 for males and from 295 to 901 for females. The age pattern of these indices suggests significant improvement in early childhood mortality and increasing trends for adult males for 30-45 age group. The standardised rate of YPLL and WYPLL for males and females was highest for cardiovascular disease.

Conclusion: The increasing share of premature deaths among adults and high level of premature mortality suggest continuation of National Rural Health Mission (NRHM) and increasing programmatic attention on prevention and treatment of non-communicable diseases to save premature deaths in India.

Formatted: Font: Times New Roman

Background: Though evidences suggest reduction in infant and child mortality little is known on age and sex pattern of premature mortality in India. Using data from multiple sources, this paper estimates the age and sex pattern of premature mortality in India.

Methods: The standardised years of potential life lost (YPLL), premature years of potential life lost (PYPLL) and working years of potential life lost (WYPLL) are computed for broad age groups over two decades (1991-2011) and by selected causes of death for 2002.

Results: During 1991-2011, the age standardized rate of YPLL (per 1000 population) had declined from 310 to 235 for male and from 307 to 206 for females. The estimated YPLL (in million) had declined from 134 to 147 for male and from 123 to 108 for females. The YPLL for adult (aged 15-65) has increased by 32% for males and 28% for females during the same time. The standardized PYPLL (per 1000 population) has declined from 259 to 137 for males and from 258 to 115 for females during the same period. The estimated PYPLL for adult males has increased by 13% and by 32% in 30-45 age group. The standardized rate of WYPLL has declined from 274 to 131 for males and from 295 to 901 for females. The age pattern of these indices suggests significant improvement in early childhood mortality and increasing trends for adult males for 30-45 age group. The standardised rate of YPLL and WYPLL for male and female was highest for cardiovascular disease.

Conclusion: The increasing share of premature deaths among adults and high level of premature mortality suggest continuation of National Rural Health Mission (NRHM) and increasing programmatic attention on prevention and treatment of non-communicable diseases to save premature deaths in India.

Formatted: Font: Times New Roman

Background:mortalityDemographic and epidemiological transition in India has resulted in large working age population and rise in non communicable diseases at a faster pace than predicted. Early onset of non communicable diseases are primarily affecting the working age population those are premature and avoidable.Using data from multiple sources,this paper examines estimates the age and sex pattern of premature mortality in India.

Methods: The premature mortality is measured with a set of indices; years of potential life lost (YPLL), premature years of potential life lost (PYPLL) and working years of potential life lost (WYPLL). All the indices were standardised, and their corresponding rates have been calculated for broad age groups from 1991 to 2011 and also by selected causes of death for 2002.

Results: During 1991-2011, (per 1000 population) the age standardized rate of YPLL had declined from 310to 235.2 for male and from 307 to 206 for females per 1000 population. The standardized PYPLL (per 1000 population in 0-65 age) has declined from 259.4to 136.9for males and from 257.6to 115.2 for females during the same period. and The standardized WYPLL has declined from 274.2to 130.7 for males and from 294.8to 90.6 for females. Though the age pattern of these indices suggests significant improvement in early childhood mortality,PYPLL and WYPLL both are maximally contributed by the age group 0-4 years among both male and female. Afterwards, it decline in the age group 5-14 years but again increases among adults e.g. 15-65 years.for In 2002, the WYPLL due to cardiovascular diseases was 265.7 million among males and 154.7 million among female.

Conclusion: The increasing share of premature mortality among adults and high level of premature mortality warrants continuous scrutiny of the existing programmes like National Rural Health Mission (NRHM), Maternal and Child Health (MCH) etc. and increasing attention slower pace of decline in overall premature mortality during 1991-2011 warrants the urgent need to devise strategies on prevention and treatment of non communicable diseases

Formatted: Line spacing: Double

Formatted: No underline, Underline color: Auto, Pattern: Clear

Formatted: No underline, Underline color: Auto, Pattern: Clear

Formatted: Font: Times New Roman

~~to save premature deaths in India.~~ **Keywords:** Premature mortality, YPLL, PYPLL, WYPLL, Causes of death

Strengths and limitations of this study:

This is the first ever study that provides the trends in standardised estimates of premature mortality (YPLL, PYPLL and WYPL) by age and sex in India ~~over two decades~~. It also estimate~~d~~ds the standardised indices by cause of death. However, the study ~~has two main limitations. First, it~~ could not analyse the trends and ~~state~~ pattern in cause specific estimates for the states of India due to unavailability of reliable data over time. ~~could not provide the state level estimates of the indices as the data on cause of death was available only at national level. Second, the trends in cause specific estimates could not be carried out due to data constraints.~~

Formatted: Font: Times New Roman

Age and sex pattern of premature mortality in India

Introduction

Premature mortality by age 60 ~~years~~ accounts one-third of the total deaths in low and middle income countries in 2008 [1]~~(WHO, 2008)~~. While the share of under-five mortality in premature mortality remained high in selected countries, the share of adult mortality is on the rise. The higher level of premature mortality is ~~Premature mortality accounts one third of the total deaths in developing countries (REF). While the share of under five mortality remained high in selected countries, the share of adult mortality is on~~ the ~~rise. Prevention of premature deaths and improving the adult health is increasingly themajor public health challenges in developing world. This is~~ ~~mainly~~~~largely~~mainly due to the demographic and epidemiological transition that has altered the level of mortality and disease pattern across the age groups [2, 3]. The Non-communicable Diseases (NCDs) are the leading cause of death and ~~it is~~ primarily affecting the working age group [4, 5]. Studies suggest that premature deaths and hospitalisation adversely affect~~s~~ economic growth and development [6-8]. The estimated loss of GDP in 2004 due to Cardiovascular Disease (CVD) alone was about `one trillion in India [8].

~~Mahal [7]estimated one trillion rupees loss of GDP in 2004 due to Cardiovascular Disease (CVD) in India.~~

The concept of premature mortality was evolved to measure the increasing social and economic cost of mortality at younger age because the conventional measure such as crude death rate and age specific death rate does not quantify the extent of life years lost at early ages [9]. The premature mortality is the best single proxy measure for reflecting differences

Formatted: Line spacing: Double

Formatted: Font: Not Bold, Not Highlight

Formatted: No underline, Underline color: Auto, Pattern: Clear

Formatted: Font: Rupee Foradian

Field Code Changed

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Font: Times New Roman

in the health status of thestate's populations [10]. A number of measures have beenare wasere developed and used to quantify the extent of premature mortality; e.g.. These includes preferably potential years of the life lost (PYLL), premature years of potential life lost (PYPLL), the working years of potential life lost (WYPLL) and the valued years of potential life lost (VYPLL). Each of the method is a function of age at death death and and the number of deaths at that age [11] but . However, they variedy with respect to weight and upper and lower limit of the age. and weight given to each age.. Though many new indices have been developed to measure the premature mortality like DALY (Disability adjusted life years), HALY (Health adjusted life years), YLL (Years of life lost) etc., these are based on a number of assumptions and suffers from data limitations in Indian context. On the other hand, the YPLL, PYPLL and WYPLL capture the premature mortality as it is based on fewer assumptions and data input.

The potential years of life lost (PYLL) is the most commonly used indicator to quantify premature mortality. A large number of studies estimated the PYLL to rank the cause of death and understand level, pattern and differentials in mortality by income, gender, ethnic groups and regions. Ranking of the major cause of premature mortality using PYLL revealed that accidents (38.66%) accounts for largest PYLL followed by circulatory system (24.85%) and Neoplasms (15.67%) in Canada [12]. The PYLL varies largely among OECD countries and by sex. Among the females, the estimateds PYLL (per 1000) was highest in Russian Federation (7.1) and lowest in Iceland (1.5). Among males, the PYLL was 20.2 in Russia and 3.0 in Iceland [13]. Using mortality data over four decades, studies found absolute and relative decline in premature mortality across socio-economic and racial/ethnic group during the early period (1966-80) and widening relative health inequalities in the subsequent period

Formatted: Font: Times New Roman

(1980-2002) [14]. The large health disparities between African American and other ethnic groups in San Francisco were estimated using expected years of life lost. With respect to gender, the estimated years of life lost among males wereas 73,627 and 51,194 among females. The estimated the premature deaths by cause in developing countries showed ( ) as the major cause of death [15]. The leading causes of premature deaths were HIV/AIDS followed by suicide and drug overdose among males among males and lung cancer, breast cancer and hypertensive heart diseases among females [15]. Studies also suggests that the association betweenof income and premature mortality (deaths before age 75) was stronger among low-income counties compared tothan high-income counties. Among carious income group, Tthe premature mortality varies by geographic, socio-demographic, racial/ethnic and behavioralbehavioural factors among income groups [15].

The potential years of life lost (PYLL) is the most commonly used indicator to quantify premature mortality.A large number of studies estimated the PYLL to rank the cause of death and understand level, pattern and differentials in mortality by income, gender, ethnic groups and regions. Romeder and McWhinnie [10]rank the major cause of premature mortality by focussing on PYLL in age group 1 and 70 and found that accidents (38.66%) accounts for the maximum PYLL followed by circulatory system (24.85%) and Neoplasms (15.67%).The level, pattern and cause of adult mortality in selected developing countrieshas been estimated, also the YPLL using an age weight of 85 years minus the age at death[11].The Organisation of Economic Cooperation and Development [12]measured premature mortality with the help of potential years of the life lost (PYLL) before age 70 years for its member nations and found highest PYLL in Russian Federation (20161 per thousand males for male and 7056 per thousand females for female) and lowest in Iceland (2995 per thousand males and 1492 per thousand females).The reduction in PYLL was highest in Mexico(13587 per thousand populations) during 1970-2009 and gender differentials have been found.According to a

Formatted: Highlight

Formatted: Font: Times New Roman

report issued by the US General Accounting Office in 1996, "premature mortality is the best single proxy for reflecting differences in the health status of state's populations"[13]. The potential years of life lost (PYLL) is the most commonly used indicator to quantify premature mortality. In 2009, the PYLL was 201 per 1000 males in Russian Federation (highest) followed by Newzeland (89). The gender differentials are large, higher for male than females (71 per 1000 females in Russian Federation and 28 in Newzland).A study on the fall and rise in inequalities in premature mortality(death before the age 65) in United States of America (USA) for 1960 2002 found that the premature mortality and infant mortality decreased for all income groups. Had all persons in US experienced the same yearly age specific premature mortality rates as the white population living in the highest income quintile, between 1960 and2002, 14% of the white premature deaths and 30% of the premature deaths amongpopulations of color would not have occurred.[14]. The expected years of life lost has been estimatedto rank the leading cause of deaths in San Francisco[15] and found.Llargehealthdisparities between African American and other ethnic groupswere found. In the years 2003 2004, 6312 men died (73,627 years of life lost), and 5726 women died(51,194 years of life lost).The leading causes of premature deaths arethose with the largest average YLLs and are largely preventable. Among men, these were HIV/AIDS,suicide, drug overdose, homicide, and alcohol use disorder; and among women, these were lungcancer, breast cancer, hypertensive heart disease, colon cancer, and diabetes mellitus.A study also suggests that the association between income and premature mortality was stronger among low income counties than high incomecounties. It has been also found that the differences in the pattern of risk factors between high and low income groups. Significantgeographic, sociodemographic, racial/ethnic, health care, social, and behavioral disparities exist among incomegroups.Disparities in premature mortality between high and low income countries and found strong association of income and premature mortality in low

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Font: (Default) Times New Roman, 12 pt

Field Code Changed

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Font: (Default) Times New Roman, 12 pt

Formatted: Font: Times New Roman

~~income countries than high income countries and the risk factors are different for each group[16].~~

Like other developing countries, India is also experiencing rapid demographic and epidemiological transition. While the total fertility rate is close to replacement level, the life expectancy has reached ~~to~~ 64.6 years for male and 67.7 years for female by 2008 [16]. There has been a significant reduction in~~of~~ under-five ~~mortality~~deaths in last ~~two~~ decade~~s,declined~~ from 2.5 million in 2001~~..~~ to 1.5 million in 2012 [17, 18]~~.. per 1000 live births (REF),~~ During 1991 and 201~~0~~1, the share of under-five deaths to total deaths has declined from 35% to 17% while that of adult deaths (deaths in 15-59 years) has increased from 27% ~~..~~to ~~..~~30% [19]~~(Thesis ref)~~. On the othe~~h~~r hand, the NCDs are the leading cause of mortality and morbidity in India. The non-communicable diseases (NCDs) account for 62% of the total burden of foregone DALYs and 53% of total deaths in India [20]. ~~Among all NCDs, 9.2 million productive life lost in India in 2000 due to CVD among 35-64 years age group were estimatedand projected to 17.9 million by 2030 [17]. T~~The ~~cardiovascular deaths (~~cardiovascular deaths (CVDs) ~~CVDs)~~was estimated a~~s~~t1.4 million (56.2% in 25-69 age group) in 2004 and projected at 2.1 million (45% in 25-69 age group) by 2021 [21]. The hospitalisation rate and outpatient visit due to NCDs rose from 32% to 40% and 22% to 35%, respectively, ~~within a decade from~~ during 1995 to 2004 [20].The CVDs accounted loss of 9.2 million productive life among 35-64 years age group in 2000 and projected at 17.9 million by 2030 [22]. Though a large number studies has been carried out on trends, differentials and determinant of mortality, there is no study that examined the premature mortality in India [23-26]~~(REF).~~In this context it is necessary to understand the extent of avoidable deaths ~~among working population~~ in India.

Formatted: Highlight

Formatted: Font: Times New Roman

~~Like other developing countries, India is also experiencing rapid demographic and epidemiological transition. While the total fertility rateis close to replacement level, the life expectancy has reached to 64.6years for male and 67.7 years for female by 2008 [20]. There has been a significant reduction of child mortality in last two decades. The share of child mortality to total deaths has declined from 35% in 1991 to 17% by 2011. However, the share of adult deaths (deaths between 15-59 years) is on the rise though the probability of death between 15-59 years has declined over time. The Non-communicable diseases are the leading cause of mortality and morbidity. In this context, this~~The aim of this paper is to ~~examines~~examine the age and sex pattern of premature mortality in India over last two decades (1991-2011). It also estimates the extent of premature mortality by selected causes of death for 2002. The paper has been conceptualised with the following rationale. First, evidences suggest~~s~~ increase in adult mortality in India, which are premature and avoidable. ~~the on-going demographic and epidemiological transition in India has altered the disease pattern and~~The ~~also the~~ social, psychological and economic costs associated with premature deaths are devastating.~~The NCDs are the leading cause of deaths which are more prevalent among adults~~.Hence prevention of these deaths must be a public health priority. Second, the NCDs are the leading cause of death, and the onset of NCDs ~~in India~~ is 10-15 years earlier than that of developed countries. These deaths are primarily affecting the working age group which results into rise in premature mortality. On the~~h~~ other hand, ~~and~~ the public health centers ~~publichealthsystemcentresin India~~ are not equipped enough to treat the NCDs.Third, though the premature mortality has been extensively studies in developed countries, there is no study that has estimated the level and trend of premature mortality in India. The quantification of premature mortality helps to identify the social and economic cost associated with mortality, ranks the disease burden and has greater policy relevance. In this

Formatted: Not Highlight

Formatted: Font: Times New Roman

context, this paper provides the numerical estimates on the premature deaths in India over time and by causes of death for broad age group.

Data and methods

This paper uses data from multiple sources; the census of India, 1991, 2001 and 2011, the sample registration system (SRS), 1991-2011 and report on cause of death, 2001-03 [27-31].~~This paper used published data and does not have any ethical issues.This is an independent research and did not get any funding.~~The Indian census is the largest single source of information on demographic and selected socio-economic ~~different~~ characteristics of the p~~eop~~~~le~~ulation ~~of India~~. We have used the age and sex distribution of the population for 1991, 2001 and 2011 ~~census and the intercensal population for 1996 and 2006. T~~ and the age-sex distribution of intercensal periods (1996 and 2006) ~~are borrowed~~taken from SRS.~~Medical Certification of Cause of Deaths (MCCD) is another source of information available in India but due to the very low coverage of deaths (maximum ….% in Maharashtra), it is not suitable for a representative analysis.~~

~~The d~~Data on causes of death is extremely useful for planning of health programmes and for ~~planning evidence based~~ intervention~~ist~~ strategies ~~in the country~~. The special survey of deaths (SSD) was jointly undertaken by the Office of the Registrar General, India (ORGI) and the Centre for Global Health Research (CGHR) ~~and UniversityofToronto~~[27]~~SRS in early~~ in 2004-05.~~) using anadvanced form of verbal autopsy. for the period 2001-03.The Office of the Registrar General, India (ORGI) has prepared this Report jointlywith the Centre for Global Health Research (CGHR), St. Michael's Hospital, and UniversityofToronto[21].The grouping for theCauses of Death is as per the World Health Organisation (WHO) guidelines.~~The SSDwas implemented during 2004-05 covering ~~all~~0.114 million deaths from

Formatted: Font: Times New Roman

1.1 million households, which have been recorded during 2001-2003 in Sample Registration System (SRS) [27]. The causes of death ~~have been~~was~~were~~ determined using an advanced form of Verbal Autopsy called the"RHIME" or Representative, Re-sampled, Routine Household Interview of Mortality withMedical Evaluation method. ~~The cases resulting into continuing disagreements were referred to a thirdphysician to adjudicate the final ICD 10 code~~.We have used data on the distribution of deaths by age, sex and cause from this report to estimate the premature mortality ~~due to individual causes of death.~~. We may mention that, besides these sources, the vital registration system and the Medical Certification of Cause of Deaths (MCCD) provide~~s~~ the deaths by age, sex and selected cha~~ah~~racteristics, However, the vital registration system in India is incomplete and have limited used for analyses [32] ~~(REF)~~. The ~~is a~~MCCD also have very low coverage and it is not suitable for a representative analysis [33]. ~~(REF~~nother source of information available in India but due to the very low coverage of deaths (maximum ….% in Maharashtra), it is not suitable for a representative analysis.

~~This data used is approximately thirteen years old, but since the proportion of death has not changed significantly, the results are valid and useful in the current scenario. (I wll compare with GBD, 2010)~~

~~Methodology~~

This paper use three indices, namely, the YPLL, PYPLL and WYPL and .the standardised rates to understand the ~~have been used to quantify the~~extent of premature mortality in India. In case of standardised rates, the age distribution of Kerala, 2011 is used as the ~~refernce~~reference population because the Kerala is demographically advanced state of India.

Formatted: Highlight

Formatted: Highlight

Formatted: Font: Times New Roman

The three year moving average of the ASDR is used. Age group 15-65 years is referred as adult age. The analysis has been carried out for India. The method of computing each of the indices is given below ~~as described below~~:

a. Years of Potential Life Lost (YPLL)

The ~~potential years of life lost (~~YPLL ~~)~~is a summary measure of premature mortality that gives higher weight to deaths occurring at younger age and lower weight to the deaths at higher ages. It~~involves e~~estimat~~inges~~ the average ~~time~~years a person would have lived had he or she not died prematurely[11]. The method used in this study is given by:

$$\boldsymbol{YPLL = \sum_{i=0}^{\infty} d_i * L_i} \quad \textbf{(1)}$$

w~~W~~here L_i is the life expectancy at age i, d_i is the number of deaths at age i.
The deaths are ~~are~~ weighted by life expectancy at each age.

The standardised YPLL and corresponding rates have been calculated as follows[12]:

$$\textbf{Standardized YPLL} = \boldsymbol{YPLL} * \left(\frac{P_{ir}}{N_r}\right) * \left(\frac{N}{P_i}\right) \quad \textbf{(2)}$$

Where $P_{i,r}$ is population in the i^{th} age group in the reference population (Kerala);
N_r is the total reference population (Kerala)
N is the total study population;
P_i is the population in the i^{th} age group in the study population.

$$\textbf{Rate of YPLL} = \frac{\sum \boldsymbol{YPLL}}{N} * 1000 \quad \textbf{(3)}$$

b. Premature years of potential life lost (PYPLL)

Formatted: Font: Times New Roman

The PYPLL measures the loss of years of productive life due to death before a cut-off age. The upper age limit on estimating PYLL varies by countries and authors ~~Different age limit could be taken to define premature death, however many studies have considered death before age 65 years as premature death~~[11]. ~~,~~ We have used the upper age limit of 65 years, close to the average longevity in India

$$PYPLL = \sum_{i=0}^{UN} d_i * (NU - i) \quad \text{(4)}$$

~~W~~where d_i is the number of deaths at age i,

U is the ~~We have used 65 as the~~ upper ~~cut off~~limit of age (65 years).

In each age, the deaths are weighted by difference in upper age limit and age at death.

$$\text{Standardized PYPLL} = PYPLL * \left(\frac{P_{i,r}}{N_r}\right) * \left(\frac{N}{P_i}\right) \quad \text{(5)}$$

~~W~~where $P_{i,r}$ is the population in the i^{th} age group in the reference population (taken as Kerala);

N_r is the total reference population in age group 0 to 65 (taken as Kerala);

N is the total study population in age group 0-65;

P_i is the population in the i^{th} age group in the study population.

$$\text{Rate of PYPLL} = \frac{\sum PYPLL}{N} * 1000 \quad \text{(6)}$$

~~W~~where N is the total population in age group 0 to 65.

c. Working years of potential life lost (WYPLL)

The WYPLL measures the working life years lost during "the working age period" in a population.

$$WYPLL = \sum_{i=0}^{W-1} d_i * (U - W) + \sum_{i=W}^{N} d_i * (U - i) \quad \text{(7)}$$

~~W~~where $d_i$is the number of deaths at age i,

~~N~~ U is the upper cut off age (65 years);

Formatted: Font:
Formatted: Line spacing: Double
Formatted: Font:
Formatted: Font:
Formatted: Font:
Formatted: Line spacing: Double
Formatted: Line spacing: Double
Formatted: Left
Formatted: Font: Times New Roman

W is the lower cut-off age (14 years).

~~In computing the WYPPL, the lower limit of 14 and upper limit of 65 is taken.~~

Here a constant weight is assigned to the deaths before age 14 years; difference in upper and lower age cut-off and deaths at age 14 and above are weighted by difference between upper age limit and age at death.

Standardized WYPLL = $WYPLL * \left(\frac{P_{i,r}}{N_r}\right) * \left(\frac{N}{P_i}\right)$ **(8)**

w~~W~~here $P_{i,r}$ is population in the i^{th} age group in the reference population (taken as Kerala);

N_r is the total reference population in age group 0 to 65 (taken as Kerala);

$N$is the total study population in the age group 0 to 65;

P_i is the population in the i^{th} age group in the study population.

Rate of WYPLL=$\frac{\sum WYPLL}{N} * 1000$ **(9)**

w~~W~~here N is the total study population in the age group 0 to 65 years.

The estimated population and deaths by age and sex over 1991-2011 is shown in Appendix 1 and 2. ~~Kerala is demographically most advance state of India with lowest mortality level, that's why it is assumed as a reference or goal for India.~~

Cause specific indices of premature mortality

We have also computed the YPLL, PYPLL and WYPLL~~were calculated~~ for selected causes of death using the similar methods and weighting procedure ~~above methods~~ for 2002. The distribution of deaths by ~~diseases specific deaths are taken from the distribution of death by~~ cause, age and sex and taken from Report on Causes of Death, RGI, 2001-03. The weight~~ing~~ assigned for each age group is inbuilt in the each of the indices. In general, in each of the method, the younger age groups get~~s~~ a higher weight age and the older age group gets a lower weight~~age~~.

Formatted: Font:
Formatted: Line spacing: Double
Formatted: Font:
Formatted: Font:
Formatted: Line spacing: Double
Formatted: Font: Times New Roman

Funding and Ethical Issues:

It -is an independent research and did not receive any funding. We have used published data and it does not involve any ethical issues.

Results

Results are presented in two sections. Section 1 describes the ~~level and~~ trend of premature mortality by age and sex and section 2 describe~~presents~~ the estimated years of premature deaths by causes of death.

Section 1: Trends in ~~Indices of P~~premature ~~M~~mortality by age and sex, 1991-2011 ~~: YPLL, PYPLL and WYPLL~~

Table 1 presents the standardized YPLL in millions for a period of two decades (1991-2011) by broad age group and sex. During 1991-2011, the YPLL has increased from 134~~.1~~million to 14~~6.67~~ million among males while it has declined from 123~~.2~~ million to 10~~87.9~~ million among female~~s.~~. The rate of YPLL has declined from 310 to 235~~.2~~ per 1000 population for males and from 30~~6.97~~ to 206 for females in the same period. Though the overall decline in YPLL reflects the marked improvement in mortality in the population, it conceals large discrepancies in broad age group. The decline in YPLL was significant among younger age group, particularly among children while it has ~~remained similar or~~ increased among adults (15-64 years). Among children under five years of age, the YPLL has declined by 38% for male and 32% for females ~~from 56.3 in 1991 to 35 by 2011 for male while among female it has declined from 53.1to 36.3among female~~ in the same period. Among adults (in 15-64 age groups), the YPLL has increased ~~during 1991-2011~~ for males in most of the ~~all the~~ age group. ~~,~~ ~~f~~For example during 1991-2011, ~~in 60-70 age group~~ the YPLL for males in 30-45 age group has increased by 48% and for 45-59 it has ~~from 13.4 million to 20 million and from12.6 to~~

Formatted: Font: Not Bold
Formatted: Line spacing: Double
Formatted: Font:
Formatted: Font: Not Bold
Formatted: Line spacing: Double
Formatted: Space After: 0 pt, Line spacing: Double
Formatted: Font: Times New Roman

~~18.7 million in the 30-45 age group.The YPLL has increased from 22.5 million in 1991 to 28.2 million by 2011 in the 45-59 age group~~increased by 25%. Among adult females, the largest decline in YPLL ~~has declined~~was in the age group ~~15~~5-~~45~~14 and increased in the age group 60-70. Though the absolute ~~l~~value of YPLL has increased during 1991-2011, the rate of YPLL has declined. Though the YPLL has declined largely for 0-4 year, it remains highest in this age group. The YPLL has not shown secular decline; had initially increased during 1991-2001 and declined thereafter. ~~With respect to elderly, the rate of YPLL has declined from 10.5 in 1991 to 26.8 by 2011 for males and 11.5 to 27.4 for females.~~

Table 1: Trends in years of potential life lost (YPLL) in million (standardised) by age and sex and rate of YPLL (per 1000 population) in India, 1991-2011

Age group	1991		1996		2001		2006		2011		Percentage reduction (1991-2011)	
YPLL in million	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0-4	56.3	53.1	50.2	48.0	62.3	60.4	45.0	41.5	35.0	36.3	37.8	31.6
5-14	7.8	7.9	7.9	8.3	7.3	7.0	7.2	6.8	5.6	5.0	28.2	36.7
15-29	10.9	13.2	11.3	13.0	13.1	14.7	13.1	12.9	12.2	11.2	-11.9	15.2
30-45	12.6	11.9	14.4	12.5	17.4	13.6	18.2	12.5	18.7	10.6	-48.4	10.9
45-59	22.5	14.9	24.6	17.2	28.1	18.7	26.5	16.7	28.2	16.9	-25.3	-13.4
60-70	13.4	10.8	17.1	13.5	18.4	14.6	18.6	15.0	20.0	15.1	-49.3	-39.8
70+	10.5	11.5	20.2	23.0	18.4	12.4	23.8	50.5	26.8	30.7	-155.2	-167.0
0-14	64.1	60.9	58.1	56.2	69.5	67.4	52.2	48.3	40.7	15.1	36.5	75.2
15-65	52.7	45.1	59.9	49.8	67.7	53.8	68.1	49.9	69.6	57.8	-32.1	-28.2
Total	**134.1**	**123.2**	**145.7**	**135.3**	**165**	**141.3**	**152.5**	**155.8**	**146.6**	**107.9**	**-9.3**	**12.4**
YPLL Rate	310.0	306.9	302.8	302.4	311.0	285.4	264.6	288.8	235.2	206.0	24.1	32.9

Formatted: Space After: 12 pt, Line spacing: 1.5 lines

Table 2 provides the ~~p~~premature years of potential life lost (PYPLL) by age and sex in last two decades. The PYP_____LL fixes an upper limit to which individual are expected to survive and measures the loss of years of productive life due to death before a selected cut-off age. During 1991-2011, the estimated PYPLL for male has declined from 10~~87.7~~ to 8~~0.9~~1 million while that of females has declined from 99~~.1~~ to 6~~3.84~~ million. ~~-~~The rate of PYPLL among males has declined from 259~~.4~~ in 1991 to 224~~.2~~ in 2001 and further to 13~~6.97~~ by

Formatted: Line spacing: Double

Formatted: Font: Times New Roman

2011. Among females, the rate of PYPLL has declined from 2587.6 in 1991 to 2132.9 in 2001 and 115.2 in 2011. The decline in PYPLL is faster among females compared to males. The differentials in PYPLL by age groups suggest that the decline is largely contributed by younger age group, particularly children under five years of age. During 1991-2011, the YPLL among children under five years of age has declined from 643.8 million years to 354.9 million years for male and from 60.1 million to 34.5 million years for females. The decline was secular for both male and females. On the other hand, in age group (15-65), the PYPLL has declined for females but not for males. The PYPLL for males in the age group 30-45 has increased from 110.8 million years to 14.2 million years and that for 45-59 it has increased from 13.6 million to 14.4 million years. Much of the gain in PYPLL was due to improvement in younger ages (below age 15 years and less at adult ages. In all the years studied, the PYPLL among males was highest in 0-4 age group followed by age group 45-59 years. Similarly for females the PYPLL was highest in 0-4 age group followed by 15-29 age group. The PYPLL was increased by 13% among adult males and declined by 20% among adult females. The increase in PYPLL among males was highest in the age group 30-45 (32%) followed by 60-65. While declining in PYPLL among children is a good sign, the increase in these indices among adult in the prime working age group is a concern. This is possibly due to increase in non-communicable diseases that are largely affecting the prime working age groups.

Table 2: Trends in premature years of potential life lost (PYPLL) in million (standardised) by age and sex and rate of PYPLL (per 1000 population) in India, 1991-2011

Age group	1991		1996		2001		2006		2011		Percentage reduction (1991-2011)	
PYPLL in million	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0-4	63.8	60.1	54.0	51.2	65.5	61.9	46.1	41.1	34.9	34.5	45.3	42.6
5-14	7.8	7.7	7.5	7.7	6.7	6.4	6.7	6.0	5.1	4.3	34.6	44.2
15-29	10.4	12.2	10.2	11.3	11.7	12.3	11.5	10.7	10.5	9.0	-1.0	26.2
30-45	10.8	9.6	11.6	9.4	13.6	9.9	14.0	8.9	14.2	7.3	-31.5	24.0
45-59	13.6	8.5	13.4	8.7	14.5	8.8	13.7	7.8	14.4	7.6	-5.9	10.6
60-65	1.3	0.9	1.6	1.1	1.4	1.0	1.6	1.1	1.6	1.0	-23.1	-11.1
0-14	71.6	67.8	61.5	58.9	72.2	68.3	52.8	47.1	40.0	38.8	44.1	42.8
15-65	36.1	31.2	36.8	30.5	41.2	32.0	40.8	28.5	40.7	24.9	-12.7	20.2

Formatted: Font: Times New Roman

Total		107.7	99.1	98.3	89.4	113.6	100.1	93.6	75.5	80.9	63.8	24.9	35.6
WYPLL Rate		259.4	257.6	212.6	208.8	224.2	212.9	170.0	147.0	136.9	115.2	47.2	55.3

Table 3 presents the working years of potential life lost (WYPLL) by age and sex for last two decades. The WYPLL gives a higher weightage to working age population. During 1991-2011, the WYPLL has declined from 1143.84 million to 77.2 million among males and from 113 million to 45 million among females. The rate of WYPLL has declined from 274.2 in 1991 to 1310.7 per 100 for males. Among females, the rate of WYPLL has declined from 2954.8 in 1991 to 910.6 in 2011. The estimate Distribution of WYPLL by age over the period of time shows a similar pattern as that of YPLL. Among females, the WYPLL has declined over all age group while for males it has declined only for younger age group. Among males aged 30-45 years, the WYPLL has increased from 9 million years in 1991 to 13.1 million years by 2011. The WYPLL was higher among females compared to males at all age group. The standardisation of WYPLL does not change the gradient across age and sex over athe period of time but level has changed.

Table 3: Trends in working years of potential life lost (WYPLL) in million (standardised) by age and sex and rate of WYPLL (per 1000 population) in India, 1991-2011

Age group	1991		1996		2001		2006		2011		Percentage reduction (1991-2011)	
WYPLL in million	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0-4	73.4	76.9	61.3	63.0	72.3	74.8	47.9	46.0	34.0	36.4	53.7	52.7
5-14	10.3	11.4	9.8	10.9	8.7	8.9	8.0	7.8	5.7	5.3	44.7	53.5
15-29	8.7	10.0	8.5	9.3	10.0	10.2	10.2	9.3	9.7	8.1	-11.5	19.0
30-45	9.0	7.7	9.7	7.8	11.6	8.3	12.4	7.7	13.1	6.5	-45.6	15.6
45-59	11.4	6.8	11.3	7.1	12.4	7.2	12.2	6.8	13.2	6.8	-15.8	0.0
60-65	1.1	0.8	1.4	0.9	1.2	0.8	1.4	1.0	1.5	0.9	-36.4	-12.5
0-14	83.7	88.3	71.1	73.9	81.0	83.7	55.9	53.8	39.7	41.7	52.6	52.8
15-65	30.2	25.3	30.9	25.1	35.2	26.5	36.2	24.8	37.5	22.3	-24.2	11.9
Total	**113.8**	**113.0**	**102.2**	**99.0**	**116.3**	**110.0**	**92.1**	**78.0**	**77.2**	**45.0**	**32.2**	**60.2**
WYPLL Rate	**274.2**	**294.8**	**220.9**	**231.5**	**229.6**	**234.3**	**167.3**	**152.8**	**130.7**	**90.6**	52.3	69.3

Section 2: YPLL, PYPLL and WYPLLPremature mortality by causes of death

Table 4 and figure 1, 2 and 3 presents the indices of premature mortality by causes of death for male and female. ~~Given the increase in adult mortality, w~~We have taken top nine causes of death among adults and computed ~~the indices of premature mortality~~ YPLL, PYPLL and WYPLL. These indices were ~~limited~~estimated ~~to t~~for the year 2002 because the causes of death data were available only for this period. Among the nine leading causes of death, the CVD account for maximum loss in YPLL and WYPLL.

The WYPLL among males was 26~~5.7~~ million due to CVD~~S~~s, ~~followed by~~ 12~~.1~~ million due to Tuberculosis and 11~~.5~~ million due to Diarrheal diseases. The rate of WYPLL among males was also maximum for CVDs (50~~49.6~~) followed by Tuberculosis (23~~.3~~) and diarrheal diseases (22~~.2~~). Similarly, for females, the WYPLL was highest for CVDs (15~~4.7~~ million) followed by Diarrheal diseases (14~~.1~~) and malignant and other neoplasms (8~~.5~~). Among males, the YPLL was highest for CVDs (21~~0.7~~) followed by diarrheal diseases (12~~1.6~~) and Tuberculosis (9). For females, the YPLL was highest for CVDs (17~~6.8~~) followed by diarrheal diseases (9~~8.9~~) and Respiratory diseases (8~~.1~~). In terms of PYPLL, among males, the PYPL rate was highest for diarrheal diseases (9~~.1~~) followed by CVDs (8~~7.6~~) and accidents (7~~6.6~~). In the case of females also, the rate of PYPLL was highest due to diarrheal diseases (11) followed by CVD (4~~.5~~) and accidents (4~~.2~~). The corresponding rate of the YPLL, PYPLL and WYPLL shows the same trend for the given causes of deaths.

Table 4: ~~Rate and absolute number~~Estimates of YPLL, PYPLL and WYPLL and the corresponding rates by cause~~,~~ in India, 2002

Causes of death	Rate (per 1000 population)						Absolute number (million)					
	YPLL		PYPLL		WYPLL		YPLL		PYPLL		WYPLL	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Tuberculosis	16.7	13.0	9.7	7.7	23.3	14.2	9.0	6.6	5.0	3.7	12.1	6.8
Diarrheal diseases	21.4	17.6	17.6	23.0	22.2	29.4	11.6	8.9	9.1	11.0	11.5	14.1
Malaria	7.9	7.8	5.9	7.2	8.8	10.4	4.3	4.0	3.1	3.5	4.6	5.0
Malignant and other neoplasms	11.9	14.6	6.2	7.1	16.4	17.8	6.4	7.3	3.2	3.4	8.5	8.5
CVD	38.2	33.3	14.6	9.5	49.6	30.7	20.7	16.8	7.6	4.5	25.7	14.7
Respiratory diseases	15.5	16.0	4.0	3.3	18.3	13.5	8.4	8.1	2.1	1.6	9.5	6.5
Digestive diseases	9.7	5.9	5.9	3.8	13.2	6.9	5.2	3.0	3.1	1.8	6.9	3.7

Formatted: Line spacing: Double

Formatted: Line spacing: Double

Formatted: Font: Times New Roman

Unintentional injuries: Other Accidents	16.1	10.4	12.7	8.8	17.9	12.3	8.7	5.2	6.6	4.2	9.3	5.9
Intentional injuries: Suicide	7.3	7.3	5.8	5.8	8.6	7.1	3.9	3.7	3.0	2.8	4.5	3.4

Figure 4 and 5 depicts the age pattern of WYPLL for top three causes of death among male and female respectively. ~~It is clear from both the figures that t~~The Diarrheal diseases accounts for the majority of the years lost among children (0-14 years) whereas CVD accounts for the highest life years lost among adults and old population. The adult population is affected by both communicable and non-communicable diseases. For example, among males, CVD and Tuberculosis ~~both~~ are ~~remarkably~~ high in ~~the~~ adult ages. Similarly, among adult females, CVD and Malignant and other neoplasms are leading causes of premature mortality. ~~Hence, the adults of India are facing the dual burden of diseases which leads to the increase in premature mortality and lowering their health status.~~

Discussion and Conclusion

The concept of premature mortality has been used as an important measure of health status and a guide for ~~–~~ health policies of many developed countries. Estimate~~sing the extent~~ of premature mortality and understanding the factors affecting ~~–~~premature mortality are prerequisite~~essential~~ in reducing avoidable mortality and improving the health of the population and. In last two decade, India has made significant progression in reduction of infant and child mortality and improvement in longevity. The increase in this~~ese~~ health outcome is~~are~~ evident across socio-economic groups and space. A number of studies have helped ~~us~~ in understanding the differentials, determinants and inequality in infant and child mortality in India [17, 34-36] ~~(REF)~~. However, evidences suggest~~s~~ increasing adult mortality ~~largely~~ and there are limited studies that covered the premature mortality in India. In this

Formatted: Line spacing: Double

Formatted: Check spelling and grammar
Formatted: Check spelling and grammar
Field Code Changed
Formatted: Check spelling and grammar
Formatted: Check spelling and grammar
Formatted: Check spelling and grammar
Formatted: Font: Times New Roman

context, we have attempted to provide the numerical estimates on premature mortality using a set of indices by age and sex over two decades. We have used the published data from SRS, special survey on cause of death –and estimated the YPLL, PYPLL and WYPLL for broad age groups. Though the estimates on premature mortality by cause of death are~~is~~ 13 years old, the inferences will not change because of increasing NCDs. The following are the~~our~~ salient findings.

Formatted: Font: Not Bold

First, we found a decline in premature mortality indices (YPLL, PYPLL and WYPLL) and their rates for both male and female except YPLL for males. This is consistent with the overall improvement in health situation of the population. Second, the decline in premature mortality indices conceals large differential across the age group and sex. While the decline in premature mortality indices is largely due to improvement in mortality in the younger age group e.g. 0-14 years, it has indeed increased among male adults. Third, the age pattern of the indices reveals that the ~~estimates of the~~ premature mortality ~~are~~ continued to be highest in 0-4 age group though the decline was highest in th~~is~~e same age group; ~~–~~ declined by more than one-third in last two decades. However, all these indices has increased in 35-49 age group suggesting increasing in ~~premature mortality these indices~~ adult male mortality. Fourth,~~Third,~~ the YPLL and WYPLL was highest due to CVDs for both male and female. Most of the CVD deaths are premature and affecting the prime working age groups. Fifth~~Fourth,~~ the estimates of PYPLL was highest for Diarrheal diseases followed by CVDs. This is because the PYPLL gives a higher weightage to children and the diraeeal diseases are higher among children.

From the above findings, it is clear that the level of premature mortality in India is higher than many developing and developed countries. The level of premature mortality is high not

Formatted: Font: Times New Roman

only because of higher under-five mortality but also due to higher adult mortality. While the existing programme in reduction of under--five mortality should continue, the programme need to be intensified for reduction of adult mortality. Reduction in adult mortality can be achieved by -increasing budgetary spending for NCDS of central and state government that would help to intensify efforts on prevention and management of NCDs. Large scale investment on medical infrastructure for NCDs and increase coverage of health insurance will be helpful in this direction. The policies to reduce production and consumption of alcohol and tobacco and creating awareness on healthy life style can reduce the risk factors of NCDs and avoidable mortality. The programme on NCDs by central government are in place and the twelfth five year plan made specific provision for management and control of NCDs under three categories; programmes for life style chronic diseases and risk factor, programmes for disability prevention and rehabilitation and health promotion and prevention of NCDs [37] ~~(REF of 12th Five Year working paper).~~. The continuation of maternal and child health programme and effective implementation of non-communicable diseases can reduce avoidable mortality in India.

~~The concept of premature mortality has been used as an important measure of health status and a guide for health policies.~~ The differentials in PYPLL by age groups suggest that the ~~decline is largely contributed by younger age group, particularly children under five years of age.~~Though the overall premature mortality indices and their rates have declined over time, . ~~The decline in premature mortality is largely due to improvement in mortality in the younger age group e.g. 0-14 years. the age pattern of YPLL, PYPLL and WYPLL reflects increased in premature mortality among male adults and older population. The decline in premature mortality is largely due to improvement in mortality in the younger age group e.g. 0-14 years. Males are experiencing more years of life lost than females. The indices have shown~~

Formatted: Check spelling and grammar
Field Code Changed
Formatted: Check spelling and grammar
Formatted: Check spelling and grammar
Formatted: Font: Not Bold
Formatted: Font: Times New Roman

declining trend for adult females but has increased for males during 1991-2011. Analysis by causes of death depicts that there are certain diseases which remarkably accounts for more years of life lost than others. YPLL was highest due to CVD followed by Diarrheal diseases and Tuberculosis and Respiratory diseases for both male and female. Diarrheal diseases accounts for highest loss in PYPLL followed by CVD and Accidents for both sex. The CVD accounts for highest loss in WYPLL both male and female followed by Tuberculosis and Diarrheal diseases for males and Diarrheal diseases and Malignant and other neoplasm for females. As most of the CVD deaths are premature and affecting the prime working age groups, it is timeto invest and devise strategies to combat the non communicable diseases particularly those are avoidable in working age groups. Diarrheal diseases, Tuberculosis and Malignant and other neoplasm are the other treats to young populationwhich are communicable in nature. The dual burden of diseases on India is the root cause of poor health status of the population as signified by the indices of premature mortality. Therefore, the increasing share of premature mortality among adults and slower pace of decline in overall premature mortality during 1991-2011 warrants the urgent need to devise strategies to combat the dual burden of diseases and save premature deaths in India.Though many new indices have been developed to measure the premature mortality like DALY (Disability adjusted life years), HALY (Health adjusted life years), YLL (Years of life lost) etc., theseare based on a number of assumptions and suffers from data limitations in Indian context. On the otherhand, the YPLL, PYPLL and WYPLL are simple to compute and capture the premature mortality as it is based on fewer assumptions and data input.

This data used is approximately thirteen years old, but since the proportion of death has not changed significantly, the results are valid and useful in the current scenario. (I wll compare with GBD, 2010)

Formatted: Line spacing: Double, Adjust space between Latin and Asian text, Adjust space between Asian text and numbers

Formatted: Font: Times New Roman

~~Though many new indices have been developed to measure the premature mortality like DALY (Disability adjusted life years), HALY (Health adjusted life years), YLL (Years of life lost) etc., theseare based on a number of assumptions and suffers from data limitations in Indian context. On the otherhand, the YPLL, PYPLL and WYPLL are simple to compute and capture the premature mortality as it is based on fewer assumptions and data input.~~

Summary box

What is already known on this ~~o~~Subject?

In last two decades, along with socio-economic development, India has made significant improvement in health outcome. While the life expectancy at birth has increased, the infant mortality rate and child mortality rate has declined across socio-economic groups. The diseases pattern is changing fast and the non-communicable diseases are the leading cause of death in India. The premature mortality is resultant of low child survival and increasing NCDs in India. ~~The demographic and epidemiological transition inIndiahas resulted increase in non communicable diseases across socio economic groups and space. Studies suggest increase in premature mortality in prime working age group. A number of indices~~

Formatted: Line spacing: Double

Formatted: Font: Not Bold

Formatted: Justified, Line spacing: Double

Formatted: Line spacing: Multiple 1.15 li

Formatted: Line spacing: 1.5 lines

Formatted: Font: Times New Roman

Formatted: Line spacing: Multiple 1.15 li

What does this study add?

This study adds to the available literature on premature mortality by providing the standardised estimates of premature mortality by age and sex in India over two decades. It also suggests that the premature mortality is on rise among men in prime working age group. The cardiovascular disease is the leading cause of premature mortality followed by diarrheal diseases.

Author's Contribution: MD and SKM conceptualised the paper, prepared analytical plan and drafted the paper.

Conflict of Interest: None

Funding and Ethical Issues: It is an independent research and did not receive any funding.

Data Sharing: Data used in this paper is available in public domain.

Formatted: Line spacing: 1.5 lines

Formatted: Font: Times New Roman

~~**Author's Contribution:** MD conceptualised and prepared tables. MD and SKM prepared analytical plan and drafted the paper.~~

Figure 1: YPLL (in million) for top nine causes of death among adults by sex in India, 2002

Figure 2: PYPLL (in million) for top nine causes of death among adults by sex in India, 2002

Figure 3: WYPLL (in million) for top nine causes of death among adults by sex in India, 2002

Figure 4: Standardised WYPLL by top three diseases and age among males in India, 2002

Figure 5: Standardised WYPLL by top three diseases and age among females in India, 2002

Formatted: Justified, Line spacing: Double

Formatted: Font: Not Bold

Formatted: Font: Not Bold

Formatted: Font: Not Bold

Formatted: Font: Not Bold

Formatted: Font: Not Bold

Formatted: Font: Times New Roman

References

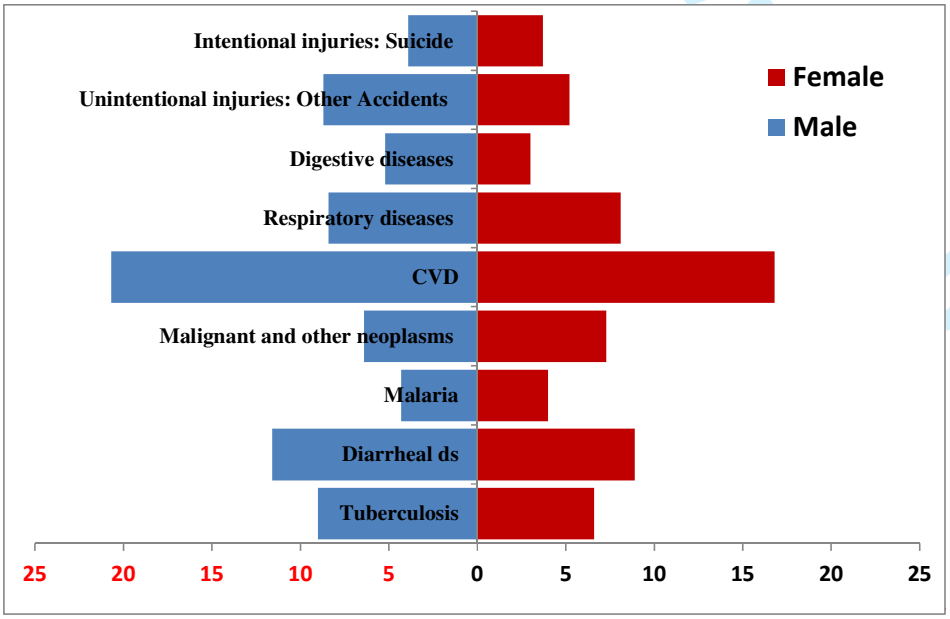
1 WHO. Premature NCD deaths: Situation and trends. Geneva: World Health Organisation 2014.
2 Joshi R, Cardona M, Iyengar S, *et al.* Chronic diseases now a leading cause of death in rural India--mortality data from the Andhra Pradesh Rural Health Initiative. *International journal of epidemiology* 2006;**35**:1522-9.
3 Quigley MA. Commentary: shifting burden of disease--epidemiological transition in India. *International journal of epidemiology* 2006;**35**:1530-1.
4 Upadhyay RP. An overview of the burden of non-communicable diseases in India. *Iranian journal of public health* 2012;**41**:1-8.
5 Goyal A, Yusuf S. The burden of cardiovascular disease in the Indian subcontinent. *The Indian journal of medical research* 2006;**124**:235-44.
6 Bloom DE, Canning D. Health and Economic Growth: Reconciling the Micro and Macro Evidence. *CDDRL WORKING PAPERS*. Stanford: Stanford University 2005.
7 Bloom DE, Canning D, Sevilla J. The Effect of Health on Economic Growth: A Production Function Approach. *World Development* 2004;**32**:1-13.
8 Mahal A. The poor and health service use in India. *Health, Nutrition and Population (HNP) Discussion Paper*. The World Bank: Washington, DC 2001.
9 Dempsey M. Decline in tuberculosis: the death rate fails to tell the entire story. *Am Rev Tuberculosis* 1947;**56**:157-64.
10 Scanlon WJ. A Health Status Indicator for Targeting Federal Aid to States. In: Fastrup J, ed. *Report to the Chairman, Committee on Labor and Human Resources, US Senate*. USA: United States General Accounting Office 1996.
11 Gardner JW, Sanborn JS. Years of potential life lost (YPLL)--what does it measure? *Epidemiology (Cambridge, Mass)* 1990;**1**:322-9.
12 Romeder JM, McWhinnie JR. Potential years of life lost between ages 1 and 70: an indicator of premature mortality for health planning. *International journal of epidemiology* 1977;**6**:143-51.
13 OECD. Premature mortality. *Health at a Glance 2011: OECD Indicators*. OECD Publishing: Organisation of Economic Cooperation and Development 2011.
14 Krieger N, Rehkopf DH, Chen JT, *et al.* The Fall and Rise of US Inequities in Premature Mortality: 1960–2002. *PLoS Med* 2008;**5**:e46.
15 Cheng ER, Kindig DA. Disparities in Premature Mortality Between High- and Low-Income US Counties. *Prev Chronic Dis* 2012;**9**.
16 RGI. SRS Based Abridged Life Tables 2003-07 to 2006-10 In: General R, ed. *SRS Analytical Studies*. New Delhi: Registrar General & Census Commissioner 2012.
17 Ram U, Jha P, Ram F, *et al.* Neonatal, 1-59 month, and under-5 mortality in 597 Indian districts, 2001 to 2012: estimates from national demographic and mortality surveys. *The Lancet Global Health* 2013;**1**:e219-e26.
18 UN. World Population Prospects: The 2012 Revision. In: Population Division DoEaSA, ed. New York: United Nations 2014.
19 Dubey M. Trends and prospects of adult mortality by cause of death in India. Mumbai: International Institute for Population Sciences 2013:117.
20 JS Thakur SP, Charu C. Garg, Shanthi Mendis and Nata Menabde. Social and Economic Implications of Noncommunicable diseases in India. *Indian Journal of Community Medicine* 2011;**36(Suppl1)**:13-22.
21 Srivastava A, Mohanty SK. Age and sex pattern of cardiovascular mortality, hospitalisation and associated cost in India. *PloS one* 2013;**8**:e62134.

Formatted: Font: Times New Roman

22 K Srinath Reddy BS, Cherian Varghese, and Anbumani Ramadoss. Responding to the threat of chronic diseases in India. *Lancet* 2005;**366**:1744-9.
23 Saikia N, Jasilionis D, Ram F*, et al.* Trends and geographic differentials in mortality under age 60 in India. *Population studies* 2011;**65**:73-89.
24 Dubey M. Trends and prospects of adult motality in India. Mumbai: International Institute for Population Sciences 2013:117.
25 Singh A, Ladusingh L. Increasing life expectancy and convergence of age at death in India. *GENUS* 2013;**69**:83-9.
26 Yadav A, Yadav S, Kesarwani R. Decelerating Mortality Rates in Older Ages and its Prospects through Lee-Carter Approach. *PloS one* 2012;**7**:e50941.
27 RGI. Report on Cause of Death in India 2001-2003. Office of the Registrar General of India 2009.
28 Census. Census of India 2011. New Delhi: Registrar General & Census Commissioner. 2011.
29 Census. Census of India 2001. New Delhi: Registrar General & Census Commissioner. 2001.
30 Census. Census of India 1991. New Delhi: Registrar General & Census Commissioner. 1991.
31 RGI. Sample Registration System Statistical Report (for the year 1991-2011). New Delhi: Office of The Registrar General, Ministry of Home Affairs, Government of India
32 India RGo. Vital Statistics of India Based on the Civil Registration System 2010. New Delhi: Office of the Registrar General of India, Ministry of Home Affairs, Government of India 2013.
33 RGI. Report on Medical Certification of Cause of Death, 2010. New Delhi 2014.
34 Mohanty SK. Multidimensional Poverty and Child Survival in India. *PloS one* 2011;**6**:e26857.
35 Saikia N, Singh A, Jasilionis D*, et al.* Explaining the rural-urban gap in infant mortality in India. *Demographic Research* 2013;**29**:473-506.
36 Singh A, Pathak PK, Chauhan RK*, et al.* Infant and Child Mortality in India in the Last Two Decades: A Geospatial Analysis. *PloS one* 2011;**6**:e26856.
37 PlanningCommission. Report of the Working Group on Disease Burden for 12th Five Year Plan. New Delhi: Planning Commission of India, Government of India 2011.

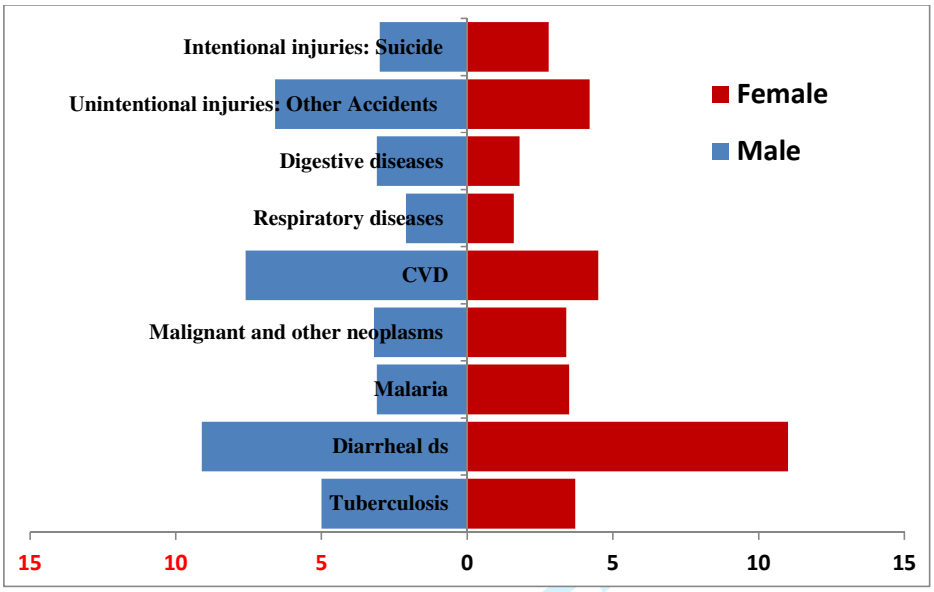
Formatted: Font: Times New Roman

~~**Figure 1: YPLL (in million) for top nine causes of death among adults by sex, India, 2002**~~

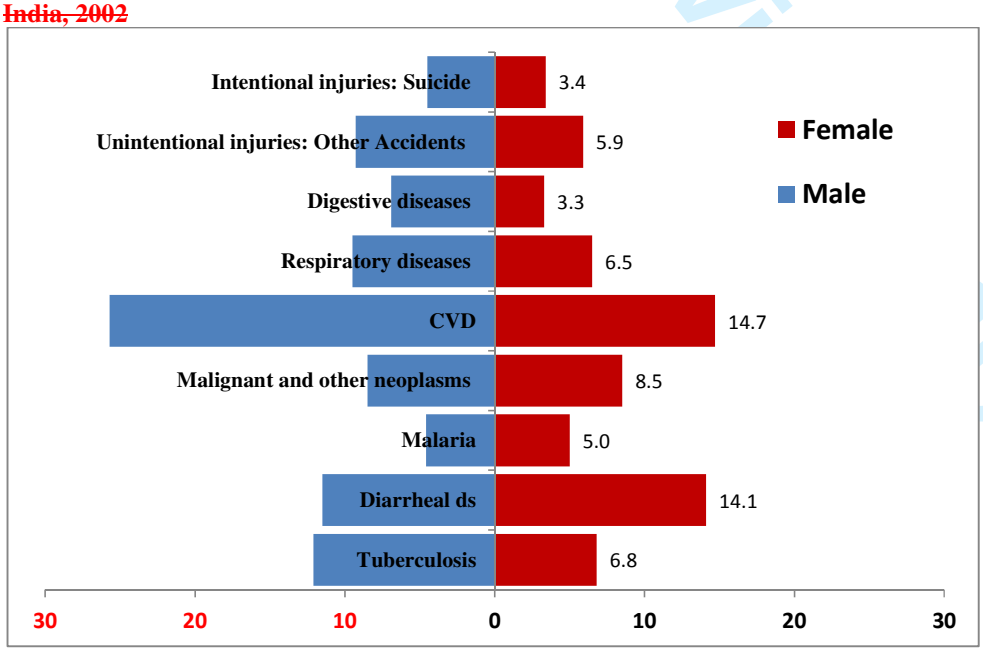


Formatted: Font: Times New Roman

~~Figure 2: PYPLL (in million) for top nine causes of death among adults by sex, India, 2002~~

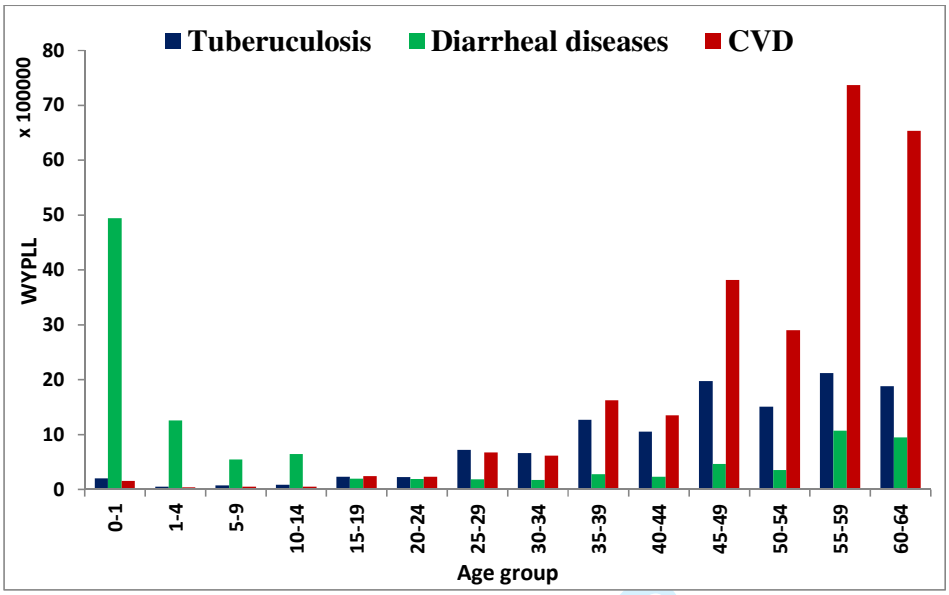


~~Figure 3: WYPLL (in million) for top nine causes of death among adults by sex, in India, 2002~~



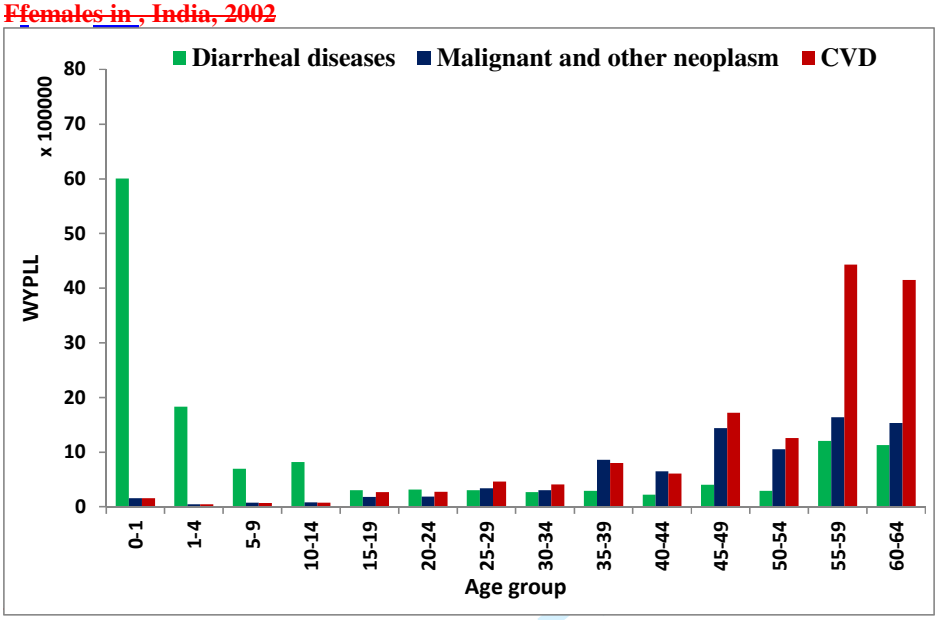
Formatted: Font: Times New Roman

Figure 4:StandardisedWYPLL due toby top three diseases byand age, among Mmale,s in India, 2002



Formatted: Font: Times New Roman

~~Figure 5: Standardised WYPLL due toby top three diseases byand age, among Ffemales in , India, 2002~~



Formatted: Font: Times New Roman

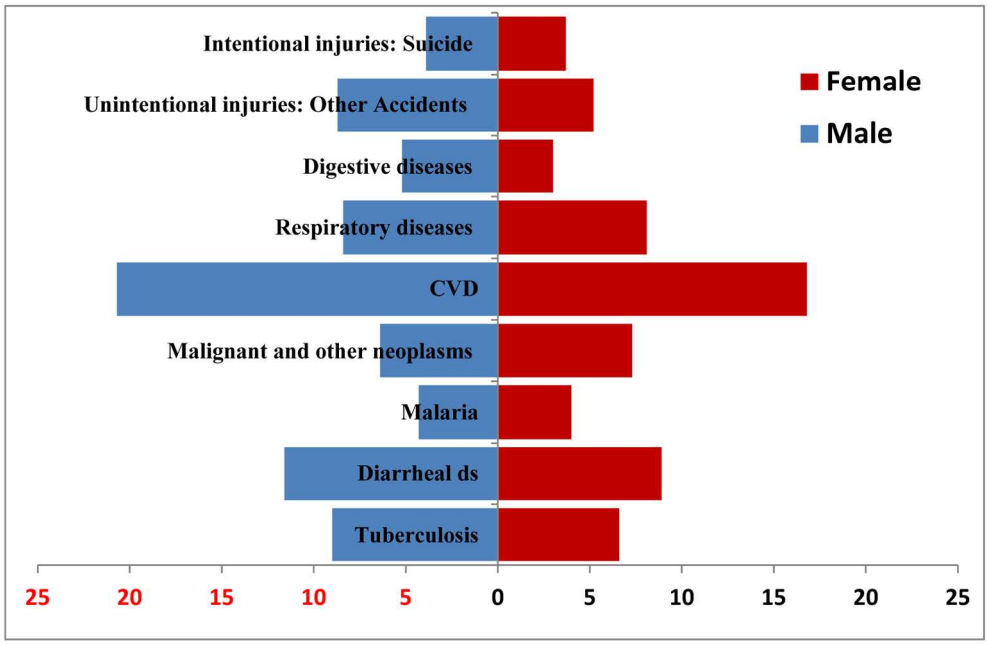


Figure 1: YPLL (in million) for top nine causes of death among adults by sex in India, 2002
147x96mm (300 x 300 DPI)

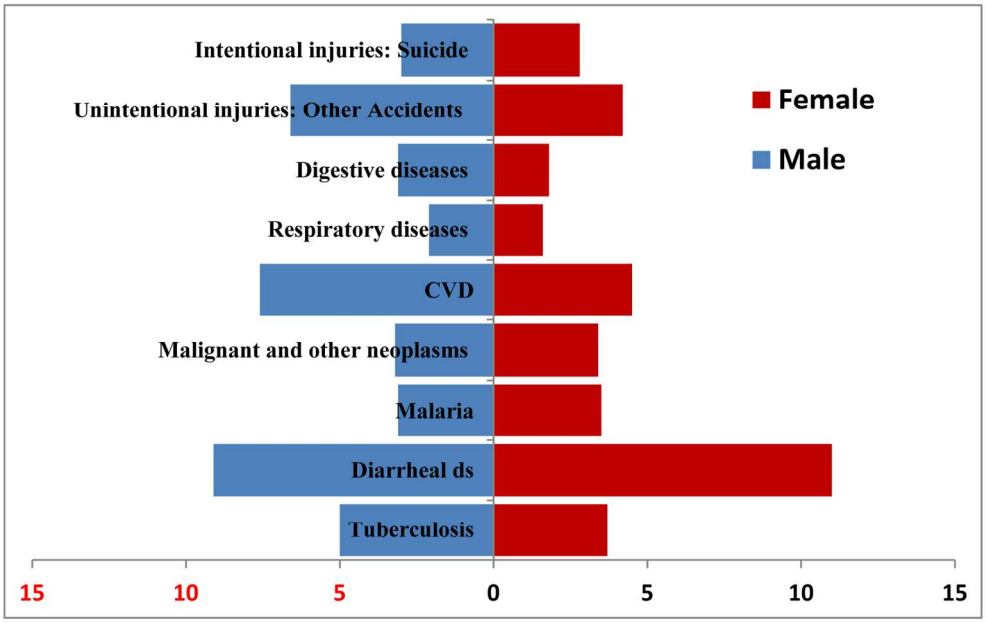


Figure 2: PYPLL (in million) for top nine causes of death among adults by sex in India, 2002
144x90mm (300 x 300 DPI)

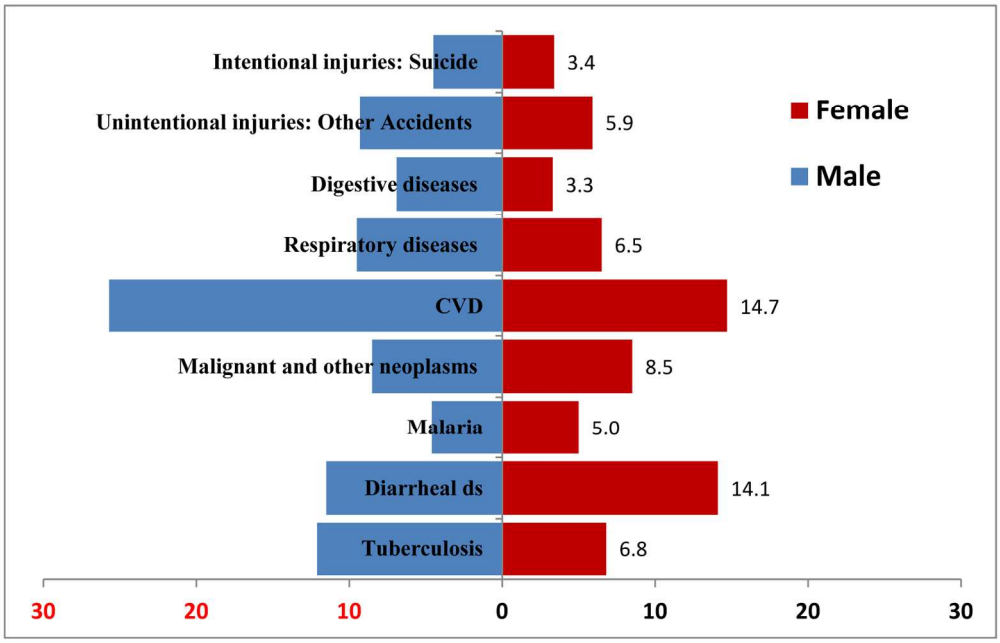


Figure 3: WYPLL (in million) for top nine causes of death among adults by sex in India, 2002
149x96mm (300 x 300 DPI)

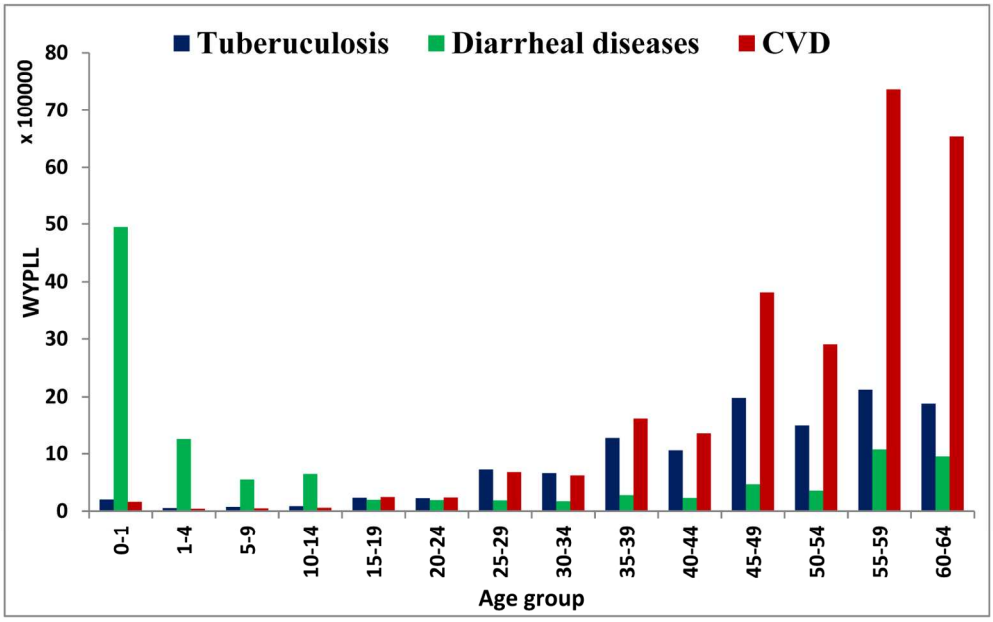


Figure 4: Standardised WYPLL by top three diseases and age among males in India, 2002
146x92mm (300 x 300 DPI)

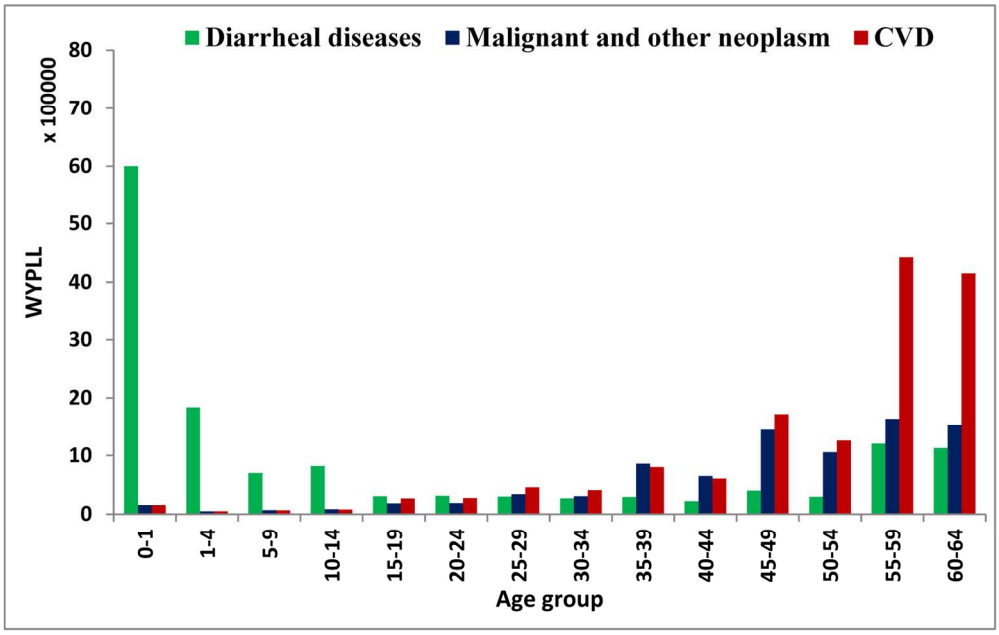


Figure 5: Standardised WYPLL by top three diseases and age among females in India, 2002
143x91mm (300 x 300 DPI)

Appendix1: Estimated population and number of deaths (in 000's) among male in India, 1991-11

	1991		1996		2001		2006		2011	
Age group	**Population**	**Deaths**	**Population**	**Deaths**	**Population**	**Deaths**	**Population**	**Deaths**	**Population**	**Deaths**
0-1	9544	1098	11404	936	8648	875	12053	750	10672	501
1-4	42816	318	43999	305	48471	250	47173	195	48171	106
5-9	57419	134	63592	127	66735	100	66701	93	66537	67
10-14	51948	70	58775	71	65633	74	67851	67	69664	49
15-19	42231	79	47212	71	53940	82	58076	84	64207	77
20-24	37514	92	43840	92	46321	100	56351	112	57787	98
25-29	34547	89	39504	101	41558	115	45426	110	51527	108
30-34	29918	98	34687	109	37362	127	43701	134	44822	130
35-39	27558	109	30833	108	36039	155	36801	150	43076	159
40-44	22842	127	26015	149	29879	163	34501	185	37681	200
45-49	18955	178	20716	173	24868	199	25875	193	32255	232
50-54	16905	212	17343	225	19852	231	22425	240	25937	267
55-59	10942	264	12526	230	13583	283	18400	282	19527	307
60-64	11907	326	12044	361	13586	329	15525	386	18770	447
65-69	6494	359	8190	353	9472	442	10350	393	12992	521
70+	10963	835	10599	974	14710	1012	14950	1252	19498	1705
Total	**432503**	**4388**	**481277**	**4385**	**530656**	**4538**	**576160**	**4626**	**623122**	**4973**

Appendix2: Estimated population and number of deaths (in 000's) among female in India, 1991-11

	1991		1996		2001		2006		2011	
Age group	**Population**	**Deaths**	**Population**	**Deaths**	**Population**	**Deaths**	**Population**	**Deaths**	**Population**	**Deaths**
0-1	8964	1040	10489	836	7913	840	11132	678	63506	483
1-4	41053	458	40030	433	45414	329	43370	232	56734	161
5-9	53876	154	58119	151	61582	111	60977	93	54021	61
10-14	46744	71	52308	70	59214	68	60438	62	50241	44
15-19	36804	100	41131	82	46276	95	51264	85	44086	79
20-24	36958	116	41578	114	43443	112	53422	110	42368	86
25-29	34693	103	38895	101	41865	111	44249	89	35014	75
30-34	28487	88	34425	95	36912	95	43709	91	30285	71
35-39	24841	85	27719	81	34535	103	33996	84	23307	72
40-44	19714	87	23695	92	25860	92	32377	97	19759	88
45-49	17179	101	18330	100	22541	111	20506	87	19029	112
50-54	14209	131	16095	149	16736	132	26441	163	13559	140
55-59	10531	168	12518	165	14070	191	16189	172	24392	184
60-64	10842	231	12518	281	13930	248	15649	289	15316	306
65-69	6365	277	8494	276	10335	346	10253	290	11912	362
70+	10111	677	11177	883	14589	504	15649	2042	20378	1459
Total	**401370**	**3887**	**447520**	**3909**	**495216**	**3487**	**539621**	**4664**	**523909**	**3783**

Research Checklist

1. Title
2. Abstract
   - Objectives
   - Setting
   - Participants
   - Primary and secondary outcome measures
   - Results
   - Conclusion
3. Keywords
4. Strengths and limitation of the studies
5. Introduction
6. Data and Methods
   - Ethical issue
   - Census of India
   - Sample Registration System (SRS)
   - Report on Causes of death, 2001-03
   - Years of potential life lost (PYLL) and its standardization
   - Premature years of potential life lost (PYPLL) and its standardization
   - Working years of potential life lost (WYPLL) and its standardization
7. Results
   - Indices of premature mortality, 1991-2011: YPLL, PYPLL and WYPLL
   - YPLL, PYPLL and WYPLL by causes of death
   - Output in tabular form
8. Discussion and Conclusion
9. Summary box
   - What is already known on this subject?
   - What does this study add?
10. Author's contribution
11. Conflict of Interest
12. Funding and Ethical Issues
13. Data Sharing

14. References