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Potential gain in life expectancy after partial and complete elimination of specified causes of death: An analysis of Medical Certification of Causes of Death data in India and its selected states

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Abstract
Information on cause of death plays an important role in mortality analysis. Knowledge about the cause of illness or death is of paramount importance for a country for upliftment of health status of people. Life table technique helps in examining the effect of specific cause of death elimination in life expectancy. One gets an idea about the gain in life expectancy if one is able to control a specific disease. The present paper aims to construct such life tables by using the data of the "Report on Medical Certification of Causes of Death 2003", Registrar General & Census Commissioner, India, in India and its selected states namely, Bihar, Maharashtra, Rajasthan and Tamil Nadu to find out the potential gain in life expectancy at birth after partial and complete elimination of specified causes of death. The elimination of diseases of the circulatory system yields maximum gain in life expectancy at birth in India and all the selected states. Effective intervention needs to be put in place so as to minimize the risk of the disease. Longevity may increase after partial and complete elimination of causes of death.

Keywords: Life table, longevity, Medical Certification of Causes of Death, potential gain, life expectancy, disease burden.

1. Introduction

Data on mortality by age, sex and cause are primary inputs for assessing population health status and a cornerstone of the evidence base for health policy in combination with other epidemiological and socio-economic information. While medically certified cause of death data from complete civil registration systems is the 'gold standard' for such statistics, these are generally not available in over two-thirds of all countries[1]. Even if the levels and trends were reliably estimated, further improvements in population health would require accurate information on cause-specific mortality to guide policy and programme priorities[2]. There are also well understood connections between temporal changes in mortality patterns and epidemiological transition making it possible to extrapolate from mortality findings to estimate fatal disease burden in a community[3].

India does not have good quality data on health situation of its population particularly the rural population where three-fourth of its total population live. Information on causes of death is of key importance in understanding the determinants of health and mortality[4]. Reddy[5] pointed out that cause of death information from hospital based data suffer from several types of selection biases and do not provide a true picture of the population. In India, reliable standardized cause-specific mortality rates are not computed because of unsatisfactory death certification even for the urban population[6,7].

Since 1949, cause-of-death statistics have been based on the underlying cause of death. The official international statistical classification defines cause of death as "the disease or injury that initiated the train of events leading directly to death, or the circumstances of accident or violence which produced the fatal injury"[8-10].

The International Classification of Disease (ICD), published by the World Health Organisation (WHO), is designed to promote international comparability in the collection, processing, classification, and presentation of morbidity and mortality data. In ICD-10 diseases have been classified under 21 categories[11].

Life expectancy (e_x) especially life expectancy at birth (e^0_0) is a good indicator of current health conditions and the most commonly cited life expectancy measure. Certainly, it can be calculated by the average number of years a person could expect to live with the life table method. The most fundamental step in life table construction is to convert age-specific death rates ($_nm_x$) to the probability of dying ($_nq_x$). The life expectancies (e_x) are derived in the last step. Life expectancy is a hypothetical measure; it is a calculable and comparable indicator. As a matter of fact, life expectancy at birth is an indicator of current health outcomes[12-14].

The measurement of cause-specific mortality is needed for several purposes *viz.*, (i) to establish the relative public health importance of different causes of death; (ii) to evaluate the probable impact of intervention programmes; (iii) to investigate the circumstances surrounding the death of children from specific causes and to devise effective actions to decrease mortality; (iv) to investigate the reason for differing rates of infant and child mortality between geographical areas; and (v) to evaluate the effectiveness of specific health intervention in controlled settings[15].

In this study an attempt has been made to construct cause of death life table and estimate cause specific death rates for India and its selected states namely Bihar, Maharashtra, Rajasthan and Tamil Nadu representing different geographical regions of the country and to estimate potential gain in life expectancy after partial and complete elimination of the specified cause of death by preparing cause deleted life tables.

Materials and Methods

Medical Certification of Causes of Death (MCCD) data for the year 2003 have been used in the study[16]. Under the Registration of Births & Deaths Act, 1969, the scheme of MCCD – an integral part of the Vital statistics System, aims at providing a reliable database for generating cause-specific mortality statistics on a regular basis[17]. The Office of the Registrar General, India (ORGI) obtains data on cause of death from the Chief Registrar of Births and Deaths of different States and Union Territories. The MCCD under Civil Registration System has been implemented in the States/UTs in a phased manner to provide data on cause of death. However, it has so far been implemented in only certain hospitals, generally in urban areas which are selected by the Chief Registrar of Births & Deaths. Thus, the scheme covers mostly those deaths, which occur in medical institutions located in urban areas. The coverage under the scheme in terms of percentage level of medical certification as well as the type of hospitals covered has not been uniform across the States/UTs. Some of the States have notified only teaching and specialized hospitals under it, whereas in others, only district hospitals and Primary Health Centers (PHCs) have been brought under its ambit.

For constructing abridged life tables Greville method has been used[18]. The values of $_nq_x$ (the probability of death between age x and x+n) have been calculated by using the relation between the probability of death ($_nq_x$) and the observed age specific death rates $_nM_x$. The $_nM_x$ values for India and its selected states are based on the MCCD 2003 data[16] and the projected urban population of the state for the year 2003[19]. Urban crude birth rate, urban crude death rate, urban infant mortality rate, urban age specific death rate and urban sex ratio have been taken from Sample Registration System (SRS)[20]. Life tables for India and selected States were prepared by using MCCD data after distributing the deaths under the head "age not stated" in all the age groups in proportion to total deaths at those age groups. These life tables were compared with SRS urban life tables of India and selected States for the year 2001-05[21]. It was observed that there are slight differences in values of both the tables. Therefore, these life tables have been used in preparing cause of death elimination tables of India and selected States. Life expectancies at birth as per SRS and as per author calculation by using MCCD data have been given under results.

The complete elimination of some causes of death is practically not possible, partial elimination can reduce the effect of these effects substantially. Therefore, to estimate gain in life expectancy after partial and complete elimination of the cause of death net probabilities of death due to causes of death have been calculated[22]. Partial elimination *i.e.*, 25%, 50%, 75% and complete (100%) elimination of six leading causes of death *viz.*, certain infectious and parasitic diseases; diseases of the nervous system; diseases of the circulatory system; diseases of the respiratory system; symptoms, signs and abnormal clinical and laboratory findings not elsewhere classified; and injury, poisoning and certain other consequences of external causes, have been summarized under results.

Results

Table 1 presents the life expectancies at birth by age and sex as per SRS urban life tables (2001-05)[21], abridged life tables and cause elimination life tables (calculated from MCCD 2003 data) after complete elimination of six leading causes of death for India and its selected states. As per author calculation, the life expectancy at birth is 69 years for male and 72.7 years for female in India; 68.2 years for male and 70.1 years for female in Bihar; 69.5 years for male and 73.3 years for female in Maharashtra; 65.9 years for male and 69.4 years for female in Rajasthan; and 69.1 years for male and 74.1 years for female in Tamil Nadu. It is evident from the above that females are enjoying more life years in India and in all the selected States.

Table 1: Life expectancy at birth from SRS urban Life Table, MCCD data abridged life table and cause of death elimination life table (MCCD, 2003)

	SRS		MCCD		I		VI		IX		X		XVIII		XIX	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
India	67.2	70.3	69.0	72.7	71.6	75.1	69.6	73.3	78.3	84.0	71.4	75.6	71.5	75.7	70.6	73.9
Bihar	67.9	67.7	68.2	70.1	71.0	72.8	73.0	72.0	78.5	81.7	68.7	72.0	68.4	70.3	70.4	74.0
Maharashtra	68.2	72.1	69.5	73.3	76.3	76.5	73.9	74.0	85.1	83.9	79.4	78.4	76.4	76.8	74.9	75.5
Rajasthan	65.7	69.2	65.9	69.4	69.2	73.4	66.6	70.4	73.5	80.9	68.0	72.4	67.4	71.7	68.5	72.5
Tamil Nadu	68.4	72.2	69.1	74.1	70.6	75.8	69.6	74.8	81.7	91.1	71.1	76.4	73.0	79.7	70.7	75.8

I	Certain infectious and parasitic diseases	VI	Diseases of the nervous system
IX	Diseases of the circulatory system	X	Diseases of the respiratory system
XVIII	Symptoms, signs and abnormal clinical	XIX	Injury, poisoning and certain other
M	Male	F	Female

Cause elimination life tables have been constructed for all causes of death after partial and complete elimination of cause of death and the results are given in tables 2 to 5.

Table 2: Potential gain in life expectancy at birth after partial (25%) elimination of cause of death (MCCD, 2003)

	I		VI		IX		X		XVIII		XIX	
	M	F	M	F	M	F	M	F	M	F	M	F
India	0.6	0.6	0.1	0.2	1.6	1.9	0.2	0.7	0.6	0.7	0.4	0.3
Bihar	0.7	0.7	1.0	0.5	1.9	2.0	0.1	0.4	0.1	0.1	0.5	0.9
Maharashtra	0.8	0.7	0.1	0.2	1.8	2.0	0.9	1.3	0.6	0.7	0.5	0.4
Rajasthan	0.8	0.9	0.2	0.2	1.4	2.0	0.5	0.7	0.4	0.5	0.6	0.7
Tamil Nadu	0.4	0.4	0.1	0.2	2.0	2.5	0.5	0.6	0.9	1.2	0.4	0.4

I	Certain infectious and parasitic diseases	VI	Diseases of the nervous system
IX	Diseases of the circulatory system	X	Diseases of the respiratory system
XVIII	Symptoms, signs and abnormal clinical	XIX	Injury, poisoning and certain other
M	Male	F	Female

The results show that there will be a minimum gain of 37 days at birth after 25% elimination of diseases of the nervous system in males in India, Maharashtra and Tamil Nadu; and diseases of the respiratory system in males in Bihar; and symptoms, signs and abnormal clinical and laboratory findings not elsewhere classified in males and females in Bihar. There will be a maximum gain of 2.5 years at birth after 25% elimination of diseases of the circulatory system in females in Tamil Nadu (Table 2).

Table 3: Potential gain in life expectancy at birth after partial (50%) elimination of cause of death (MCCD, 2003)

	I		VI		IX		X		XVIII		XIX	
	M	F	M	F	M	F	M	F	M	F	M	F
India	1.3	1.2	0.3	0.3	3.6	4.2	1.1	1.4	1.2	1.4	0.8	0.6
Bihar	1.4	1.3	2.1	0.9	4.2	4.4	0.3	0.9	0.1	0.1	1.1	1.8
Maharashtra	1.5	1.5	0.3	0.3	3.9	4.5	1.9	2.8	1.2	1.5	1.1	0.8
Rajasthan	1.6	1.9	0.4	0.5	3.1	4.5	1.0	1.5	0.7	1.1	1.3	1.5
Tamil Nadu	0.8	0.8	0.3	0.3	4.5	5.9	1.0	1.1	1.8	2.5	0.8	0.8

I	Certain infectious and parasitic diseases	VI	Diseases of the nervous system
IX	Diseases of the circulatory system	X	Diseases of the respiratory system
XVIII	Symptoms, signs and abnormal clinical	XIX	Injury, poisoning and certain other
M	Male	F	Female

The results show that the minimum gain in life expectancy at birth will be 37 days in males and females in Bihar after 50% elimination of symptoms, signs and abnormal clinical and laboratory findings not elsewhere classified; and a maximum gain of 5.9 years at birth after 50% elimination of diseases of the circulatory system in females in Tamil Nadu (Table 3).

Table 4: Potential gain in life expectancy at birth after partial (75%) elimination of cause of death (MCCD, 2003)

	I		VI		IX		X		XVIII		XIX	
	M	F	M	F	M	F	M	F	M	F	M	F
India	2.0	1.8	0.4	0.5	6.1	7.3	1.7	2.1	1.8	2.2	1.2	1.0
Bihar	2.1	2.0	3.3	1.4	6.9	7.5	0.4	1.4	0.2	0.2	1.6	2.8
Maharashtra	2.3	2.2	0.4	0.5	6.6	7.7	3.0	4.4	1.9	2.3	1.7	1.2
Rajasthan	2.4	2.9	0.6	0.8	5.1	7.6	1.5	2.3	1.1	1.7	2.0	2.3
Tamil Nadu	1.2	1.3	0.4	0.5	7.9	10.4	1.5	1.7	2.8	4.0	1.2	1.3

I	Certain infectious and parasitic diseases	VI	Diseases of the nervous system
IX	Diseases of the circulatory system	X	Diseases of the respiratory system
XVIII	Symptoms, signs and abnormal clinical	XIX	Injury, poisoning and certain other
M	Male	F	Female

The results show that the minimum gain in life expectancy at birth will be 73 days in males and females in Bihar after 75% elimination of symptoms, signs and abnormal clinical and laboratory findings not elsewhere classified; and a maximum gain of 10.4 years at birth after 75% elimination of diseases of the circulatory system in females in Tamil Nadu (Table 4).

Table 5: Potential gain in life expectancy at birth after complete (100%) elimination of cause of death (MCCD, 2003)

	I		VI		IX		X		XVIII		XIX	
	M	F	M	F	M	F	M	F	M	F	M	F
India	2.6	2.4	0.6	0.6	9.4	11.3	2.4	2.9	2.5	3.1	1.6	1.3
Bihar	2.9	2.7	4.8	1.9	10.3	11.6	0.5	1.9	0.2	0.2	2.2	3.9
Maharashtra	3.2	3.0	0.6	0.7	10.0	11.8	4.2	6.1	2.7	3.2	2.2	1.6
Rajasthan	3.3	4.0	0.8	1.0	7.6	11.6	2.1	3.1	1.5	2.3	2.7	3.1
Tamil Nadu	1.6	1.7	0.6	0.6	12.6	16.9	2.0	2.3	3.9	5.6	1.7	1.7

I	Certain infectious and parasitic diseases	VI	Diseases of the nervous system
IX	Diseases of the circulatory system	X	Diseases of the respiratory system
XVIII	Symptoms, signs and abnormal clinical	XIX	Injury, poisoning and certain other
M	Male	F	Female

The results show that the minimum gain in life expectancy at birth will be 73 days in males and females in Bihar after 100% elimination of symptoms, signs and abnormal clinical and laboratory findings not elsewhere classified; and a maximum gain of 16.9 years at birth after 100% elimination of diseases of the circulatory system in females in Tamil Nadu (Table 5).

The maximum gain in life expectancy at birth in India is due to elimination of the diseases of the circulatory system (female 11.3 years, male 9.4 years); followed by symptoms, signs and abnormal clinical and laboratory findings not elsewhere classified (female 3.1 years, male 2.5 years); diseases of the respiratory system (female 2.9 years, male 2.4 years); certain infectious and parasitic diseases (male 2.6 years, female 2.4 years); injury, poisoning and certain other consequences of external causes (male 1.6 years, female 1.3 years); and diseases of the nervous system show same gain in both male and female (0.6 years).

In Bihar, the maximum gain in life expectancy at birth is due to elimination of the diseases of the circulatory system (female 11.6 years, male 10.3 years); followed by diseases of the nervous system (male 4.8 years, female 1.9 years); injury, poisoning and certain other consequences of external causes (female 3.9 years, male 2.2 years); certain infectious and parasitic diseases (male 2.9 years, female 2.7 years); diseases of the respiratory system (female 1.9 years, male 0.5 years); and symptoms, signs and abnormal clinical and laboratory findings not elsewhere classified show same gain in both male and female (0.2 years).

In Maharashtra, the maximum gain in life expectancy at birth is due to the elimination of the diseases of the circulatory system (female 11.8 years, male 10.0 years); followed by diseases of the respiratory system (female 6.1 years, male 4.2 years); symptoms, signs and abnormal clinical and laboratory findings not elsewhere classified (female 3.2 years, male 2.7 years); certain infectious and parasitic diseases (male 3.2 years, female 3.0 years); injury, poisoning and certain other consequences of external causes (male 2.2 years, female 1.6 years); and diseases of the nervous system (female 0.7 years, male 0.6 years).

In Rajasthan, the maximum gain in life expectancy at birth is due to the elimination of the diseases of the circulatory system (female 11.6 years, male 7.6 years); followed by certain infectious and parasitic diseases (female 4.0 years, male 3.3 years); diseases of the respiratory system (female 3.1 years, male 2.1 years); injury, poisoning and certain other consequences of external causes (female 3.1 years, male 2.7 years); symptoms, signs and abnormal clinical and laboratory findings not elsewhere classified (female 2.3 years, male 1.5 years); and diseases of the nervous system (female 1.0 year, male 0.8 year).

In Tamil Nadu, the maximum gain in life expectancy at birth is due to the elimination of the diseases of the circulatory system (female 16.9 years, male 12.6 years); followed by symptoms, signs and abnormal clinical and laboratory findings not elsewhere classified (female 5.6 years, male 3.9 years); diseases of the respiratory system (female 2.3 years, male 2.0 years); certain infectious and parasitic diseases (female 1.7 years, male 1.6 years). Injury, poisoning and certain other consequences of external causes; and diseases of the nervous system have same gain both in male and female (1.7 years and 0.6 year respectively).

The elimination of diseases of the circulatory system yields maximum gain in life expectancy at birth in India and all the selected states; followed by diseases of the nervous system in Bihar, diseases of the respiratory system in Maharashtra, certain infectious and parasitic diseases in Rajasthan and symptoms, signs and abnormal clinical and laboratory findings not elsewhere classified in Tamil Nadu. The gain in life expectancy at birth after elimination of the diseases of the circulatory system was highest in female (16.9 years) and male (12.6 years) in Tamil Nadu in comparison to India and other selected states.

Discussion

This study highlights the influence of each cause of death on the mortality scenario and ascertains the effect of causes of death on life expectancy in India and its selected states. The pattern of death by cause reflects the health status of the study population and in turn provides a rational basis for health planning.

Tsai[23] found that elimination of cardiovascular disease would result in addition of 12.36 years in expectation of life at birth for combined population, 11.10 years for white males and 10.74 years for non-white males in USA. The gain in life expectancy was 12.81 years for white females and 15.66 years for non-white females.

Kulkarni[24] conducted a study in Goa and found that net gain in life expectancy at birth was 11.5 years in males and 15.2 years in females when mortality due to cardiovascular diseases was eliminated.

Jayachandran[25] constructed cause of death elimination tables by age and sex at the national level by using NFHS-1 data. All causes of death were grouped into eleven major causes *viz.*, accidents and injuries; fevers; digestive disorders; coughs; disorders of central nervous system; disease of circulatory system; other clear symptoms and cause unknown or missing. The study found that the gains in life expectancy at different ages were varied by sex and cause. The maximum gain in life expectancy at birth for males from respiratory disorders (cough) eliminated cause was 3.49 years but for females the cause was fever (3.21 years).

Indian Council of Medical Research (ICMR) conducted a study on causes of death by verbal autopsy in five selected states of India namely, Assam, Bihar, Maharashtra, Rajasthan and Tamil Nadu during 2003-2005[26]. The study found that infectious and parasitic diseases were the most common causes of death in Assam, Bihar, and Rajasthan. However, diseases of the circulatory system were the most common causes of death in Maharashtra and Tamil Nadu.

It may be mentioned here that causes of death *viz.*, certain infectious and parasitic diseases; diseases of the nervous system; diseases of the circulatory system; diseases of the respiratory system, symptoms, signs and abnormal clinical and laboratory findings not elsewhere classified; and injury, poisoning and certain other consequences of external causes constituted major portion of the total medical certified deaths in 2003 – India (75.1%), Bihar (81.5%), Maharashtra (78.9%), Rajasthan (74.5%) and Tamil Nadu (78.8%). The absolute deaths comes to 440612 in India, 4700 in Bihar, 144316 in Maharashtra, 19674 in Rajasthan, and 67117 in

Tamil Nadu. In the year 2003, the percentage of medically certified deaths to total registered deaths was only 13.5% and this pertains only to urban area. As per census 2011, around 70% (68.84%) Indian population lives in rural areas[27]. If we take into consideration the same percentage of the total medically certified deaths in 2003 and calculate the number of deaths under these six leading causes of death we would have a substantial number of deaths to be averted by eliminating these causes.

This study demonstrated the relative importance of each cause of death and has shown that longevity may be increased by how many years after partial and complete elimination of cause of death. It has implications for practical decision making in setting up health goals, allocating resources, and evaluating health programmes. Findings of the study may help planner and policy makers to take appropriate measures to reduce mortality levels. Diseases of the circulatory system seems to be the major causes of low life expectancy in almost all selected states as reflected from the analysis. If we are able to eliminate or control diseases of the circulatory system from our community expectation of life at birth will increase about 11.3 years in females and 9.4 years in males. The reduction in mortality due to these causes and its effect on the changes in life expectancy at birth is a useful way to evaluate the impact of interventions on population health.

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