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Elimination of Major Infectious Diseases and Gain in Life Expectancy in India

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Abstract

This study is carried to know the effect of infectious diseases on the mortality conditions of India. Age-cause specific deaths data have been collected from Institute for Health Matrix and Evaluation (IHME) of 2015. Using the multiple decrement life table and cause elimination life table, estimated the probability of eventually dying from the infectious diseases in the age interval $(x, x+n)$ and gain the life expectancy at birth when infectious diseases eliminated. Probability of dying of new born babies before attaining age 15 from specified causes like HIV/AIDS, TB, IID, Malaria, LRI and Diarrheal disease respectively 0.0102, 0.0063, 0.0406, 0.0092, 0.1087 and 0.0845. The most likely cause of deaths among these diseases is LRI followed by Diarrheal disease. Probability of dying in the age range 15-60 years due to HIV/AIDS, TB, IID, Malaria, LRI and Diarrheal disease respectively is 0.0369, 0.0782, 0.008, 0.0118, 0.0351 and 0.0332. Cause of death over the age range 15-60 is TB followed by the HIV/AIDS. When each cause is eliminated, Elimination of LRI gives the maximum gain in the life expectancy compared to other infectious diseases. When six major infectious diseases eliminated, additional 3.31 years of life added at the birth and elimination of other remaining infectious diseases can add the 2.75 years of life. To live the long life, eradication or prevention of infectious diseases is must necessary.

Keywords

Associated single decrement life table, Diarrheal diseases, HIV/AIDS, Life expectancy, LRI, Malaria, Multiple decrement life tables, Tuberculosis

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Introduction

A life table is a brief way of demonstrating the probabilities of an individual of a specific population living to or dying at a particular age, expected life of an individual at each age (Jose M P et. al., 2012). It is best way of explaining the summary of mortality of specified group or cohort. Life table is constructed on the basis of deaths at each age in the specified short period of time and on age specific deaths of specified cohort, so it is respectively called as current life table and cohort life table. In current life table, mortality data of short period of time such as one or three years and data of midyear population of the same period of time is used. This kind of table, tells about the mortality experience of hypothetical cohort rather than the actual cohort. This hypothetical cohort is assumed on the basis of observed age specific death rates of the current period of time. Therefore, current life table gives the snap shot of the current mortality.

In case of cohort life table, the group of people born in specific year observed each year and record death at age of each individual until no one live in the group. Practically it is impossible to trace every one of the cohorts for the long period of time (Siegel J S et al., 2004). In England and Wales, generation or cohort (born in 1876) was observed until everyone of an individual of cohort attaining age 55, meanwhile current life table constructed for the period 1871-80 to check the difference between the average remaining life of an individuals at each age of cohort and expected life at each age of period 1871-80. It was observed that cohort life table has given the more life expectancy than the current life table. As cohort goes through life, condition of mortality changes for those have lived from prior year into later years have the benefit of the improved mortality. In the recent decades not much disparities in life expectancy (Duplin and Spiegelman, 1941).

Life table is also classified by the length of age interval in which deaths data is presented. Considering the length of the age interval is one i.e. data presented in single year of age from the birth to maximum age of life is used for Complete life table. Data presented in every five or ten years of age is used for Abridge life table. Basically, in the construction of complete or abridge life table, calculate the column probability of dying at age (interval) is essential. Several authors derived the formula for the calculating the probability of dying through the observed death rate at each age (King, 1914, Reed and Merrell, 1939, Greville 1943, Sirken 1964, Keyfitz 1966, Coale and Demeny 1966 and Chiang 1968). Based on this column other columns of the life table have been generated.

In India, life expectancy at birth is 68.3 in the period 2011-2015 and 49.7 in the period 1970-74. Life expectancy is increased approximately 37% in the past four decades (SRS, 2015). When the lifespan improves, children and adults are always the result of survival progression, but according to the demographic transition stage the comparative contributions of different age groups vary (Yamunadevi & Sulaja, 2016). Demographic transition is described by the decline in the deaths in all age groups, with reduction in the adolescent mortality rate indication of survival progression in the early transition stage and mortality decreased in the older adults becoming increasingly indication of advanced transition stage (Unite states, 2012).

After construction of conventional life table considering single cause (mortality) to exiting from the cohort several authors thought of what if there were several ways to exiting from the cohort i.e. different causes of death. What is the probability of dying in the age interval (x, x+n) due to the specific cause in the presence of all other cause? What is the gain in the life expectancy after eliminating specific cause? This kind of questions can answer by the multiple decrement life tables. It is the technique in which individuals have more than one mode of exit from the cohort. After constructing the abridge life table, it can be possible to partition into several causes of death (Reed and Merrel, 1939 and Greville, 1943). The study also carried out on the elimination of specific cause from the decrement process to observe the changes in life expectancy. Such process is called Cause elimination life table. It is the gain in the life expectancy at birth when some specific cause is controlled or completely removed (Vacharangkul, 1975).

In India, control of epidemic such as small pox, malaria and tuberculosis has reduced the mortality in large extent (Sarma R, 2017). Elimination of diseases like Tuberculosis, Diarrheal diseases, Perinatal conditions and Respiratory infections have add some life expectancy compared to the all other infectious diseases (Sharnngadharan G, 2014). According to a South African study on the effects of HIV/AIDS on life expectancy, estimating that 6% of babies and up to 12% of those aged 75 would die from the disease. Majority of deaths occur in productive age groups, potentially gaining 26 years in life expectancy without HIV/AIDS (C J Mba, 2007). Using data from SRS from 2010-2013, the study assesses India's potential gain in life expectancy (PGLE) with the elimination of major causes of death. Eliminating communicable, maternal, perinatal, and nutrition-related diseases (CMPN) could potentially increase life expectancy at birth by 4.9 years, while gains for other causes vary: cardiovascular diseases (5.1 years), respiratory diseases (2.9 years), malignant neoplasms (0.9 years), injuries (1.1 years), and others (8.7 years) (Arun Jose et. al., 2021). The study reveals the potential net gain in life expectancy at birth from eliminating various causes of mortality. Complete elimination of circulatory system diseases could yield gains of 11.1 years in males and 13.1 years in females, followed by certain infectious and parasitic diseases (2.2/2.1 years), respiratory diseases (2.2/2.1 years), and injuries (1.1/0.7 years). Other notable gains include neoplasms (0.9/1.0 years), endocrine diseases (0.8/0.9 years), digestive diseases (0.8/0.4 years), genitourinary diseases (0.6/0.6 years), nervous system diseases (0.4/0.4 years), and blood-related disorders (0.2/0.3 years) (Gulati B. K et. .al, 2020).

Even though mortality rate of infectious diseases declining recently, it has still significant effect on the public health. In this chapter, we considered the major infectious diseases as causes of death to answer the questions like what is the contribution of major infectious diseases mortality to the overall mortality of India. What extent of life could be gained when each major infectious disease eliminated? What extent of life could be gained when major infectious diseases together eliminated compared to all other infectious diseases? The rest of the paper is structured as follows: First section briefs about the introduction, section 2 discusses about Methods and Materials used, section 3 focuses on results and discussion and last section concludes the study.

Methods and Materials

The data for the study is collected from the IHME, Global burden, 2015 for India. Age wise number of deaths due to six major infectious diseases i.e., HIV/AIDS, Lower Respiratory Infection (LRI), Intestinal Infectious Diseases (IID), Tuberculosis, Diarrheal diseases and Malaria were collected and age distributed population of India estimated by same source mentioned above for the year 2015 also collected. Also, all causes deaths have collected. Now age-cause specific death rate has been calculated for the year 2015. While constructing abridge life table age specific death rate and average person years survived in the age interval $(x, x+n)$ are essential columns to estimate the probability of dying between the age interval $(x, x+n)$.

This attempt made that to show the effect of these six infectious diseases on the overall mortality experience of India. The study uses the multiple decrement life table technique. This procedure is employed to know the separate effects of different cause, to estimating the probability that a person will eventually die from a particular cause or after elimination of a particular cause to see the increase in the life expectancy at birth. Before constructing the multiple life table, first must construct the conventional abridge life table.

Using ${}_n m_x$ *and* ${}_n a_x$ *to calculate* ${}_n q_x$ *:*

Age specific death rates ${}_n m_x$ can be calculated by available data of age wise deaths ${}_nD_x$ and population ${}_nN_x$. While average person's years lived in the age interval $(x, x+n)$, ${}_na_x$ has calculated as given below which was proposed by (Keyfitz, 1966)

$$ {}_na_x = \frac{-\frac{n}{24}{}_nd_{x-n} + \frac{n}{2}{}_nd_x + \frac{n}{24}{}_nd_{x+n}}{{}_nd_x} \tag{1} $$

But this formula is adequate for above age 5. The number of deaths occurred in the age interval $(x, x+n)$ involved in the equation (1). But it is calculated through the probability of dying in the age interval $(x, x+n)$, ${}_nq_x$. So, to solve this circularity problem, iteration procedure must use. Initially ${}_na_x$ is taken as $n/2$, to calculate ${}_nq_x$ through ${}_nm_x$, then one can get first set of ${}_nd_x$. Using these ${}_nd_x$ set, new set of ${}_na_x$ can be calculated by equation (1). This new set of ${}_na_x$ values again used to estimate ${}_nq_x$ through ${}_nm_x$. This process can be repeated to get the stable estimates of ${}_na_x$ and ${}_nd_x$ obtained. Two or three iterations are sufficient to get the stable estimates. But equation (1) can be used for same width of the interval n. For ${}_1a_0$ and ${}_4a_1$, adopted Coale and Demeny (1983) formulas given below

Value of ${}_1a_0$: If ${}_1m_0 \geq 0.107$ then ${}_1a_0 = 0.34$ otherwise $0.049 + 2.742{}_1m_0$

Value of ${}_4a_1$: If ${}_4m_1 \geq 0.107$ then ${}_4a_1 = 1.357$ otherwise $1.587 - 2.167{}_4m_1$

Since age specific death rate between age interval $(x, x+n)$, ${}_nm_x$ is calculated by number of deaths ${}_nD_x$ occurred in the age interval $(x, x+n)$, divided by the number of people aged in the age interval $(x, x+n)$, ${}_nN_x$ in the middle of the same year. i.e.,

$$ {}_nm_x = \frac{{}_nD_x}{{}_nN_x} \tag{2} $$

Therefore, the probability of dying between the age interval $(x, x+n)$ can be derived by

$$ {}_nq_x = \frac{n\,{}_nm_x}{1 + (n - {}_na_x){}_nm_x} \text{ and } {}_\omega q_x = 1 \tag{3} $$

Remaining columns have been calculated as follows

${}_np_x$: The probability that a person survive in the age interval $(x, x+n)$.

$$ {}_np_x = 1 - {}_nq_x \tag{4} $$

l_x: Surviving members of the cohort usually started from 100000 and it is non-increasing one.

$$ l_{x+n} = l_x - {}_nd_x \tag{5} $$

${}_nd_x$: Number of people died in the age interval $(x, x+n)$ of the cohort.

$$ {}_nd_x = {}_nq_x\, l_x \tag{6} $$

${}_nL_x$: The number of person-years lived by the l_x individuals in the age interval $(x, x+n)$.

$$ {}_nL_x = n\,l_{x+n} + {}_na_x\,{}_nd_x \tag{7} $$

Note that for open ended age interval:

$$ {}_\omega L_{85} = \frac{{}_\omega d_{85}}{{}_\omega m_{85}} $$

${}_nT_x$: Total number of person years lived after the age x i.e. total number of years lived by the cohort after age x.

$$ {}_nT_x = \sum_{a=x}^{\omega} {}_nL_a \tag{8} $$

${}_ne_x^0$: The number of years can be expected to live by the person aged x.

$$ {}_n e_x^0 = \frac{{}_n T_x}{l_x} \quad (9)$$

Multiple Decrement life table

Now, the probability of dying from specific cause ${}_n q_x^i$ is computed by applying the proportion of deaths due to the specific cause to the overall probability of dying in the age interval $(x, x+n)$, ${}_n q_x$ is given below.

$$ {}_n q_x^i = {}_n q_x \frac{{}_n D_x^i}{{}_n D_x} \quad (10)$$

Where ${}_n D_x^i$ is observed number of deaths due to specific cause between the age interval $(x, x+n)$.

${}_n d_x^i$: The number of deaths due to the specific cause in the age interval $(x, x+n)$. It can be calculated as proportion of deaths due to specific cause i to the number of deaths occurred in the age interval $(x, x+n)$ in the cohort.

$$ {}_n d_x^i = {}_n d_x \frac{{}_n D_x^i}{{}_n D_x} \quad (11)$$

${}_n m_x^i$: Age Observed age-specific death rates from specific cause i between age interval $(x, x+n)$.

$$ {}_n m_x^i = \frac{{}_n D_x^i}{{}_n N_x} \quad (12)$$

l_x^i : Number of persons reaching age x which will eventually die from the specific cause i.

$$ {}_n l_x^i = \sum_{a=x}^{\omega} {}_n d_a^i \quad (13)$$

Associated single decrement life table

It is a table that depicts the mortality experience due to a single decrement i.e. people have been exited from the cohort by single most cause. The force of mortality (decrement) associated with cause i, is μ_x^i. Since the force of mortality can be defined as $\mu_x = \lim_{n \to 0} {}_n m_x$ and force of mortality of specific cause is, $\mu_x^i = \lim_{n \to 0} {}_n m_x^i$. Hence the assumption is made that each causes are independent indicates the force of mortality of each causes is additive. i.e.,

$$ \mu_x = \mu_x^1 + \mu_x^2 + \ldots + \mu_x^k $$

Since practically in the real-life situation, it is impossible to observed directly associated single decrement processes where single cause alone is operating as decrement process. The cause we are interested in may equally be $-i$ (all causes other than i). If a table is constructed based on μ_x^{-i} it is also called as "cause deleted" life table. Since cause i is arbitrarily deleted from the set of multiple decrements. Such table still is considered as associated single decrement life table. In constructing the associated single decrement life table, the constant of proportionality for decrement other than specific cause in the age interval $(x, x+n)$, R^{-i} is computed as given below

$$ R^{-i} = \frac{{}_n D_x - {}_n D_x^i}{{}_n D_x} \quad (14)$$

The probability of surviving between the age interval $(x, x+n)$ in absence of specific cause i can be estimated using following formula (Chaing, 1984)

$$ {}_n p_x^{-i} = \left({}_n p_x\right)^{R^{-i}} \quad (15)$$

Hence probability of dying between the age interval $(x, x+n)$ in absence of specific cause i can be estimated as

$$ {}_n q_x^{-i} = 1 - {}_n p_x^{-i} \quad (16)$$

${}_n a_x^{-i}$: The average person years lived in the the age interval $(x, x+n)$ in absence of specific cause i for under 10 and greater than 10 age groups respectively following formulas are used

$$ {}_n a_x^{-i} = n + R^{-i} \frac{{}_n q_x}{{}_n q_x^{-i}} \left({}_n a_x - n \right) \qquad (17) $$

and

$$ {}_5 a_x^{-i} = \frac{ -\frac{5}{24}\, {}_5 d_{x-5}^{-i} + \frac{5}{2}\, {}_5 d_x^{-i} + \frac{5}{24}\, {}_5 d_{x+5}^{-i} }{ {}_5 d_x^{-i} } \qquad (18) $$

The remaining columns of the associated single decrement or cause elimination life table like, ${}_n d_x^{-i}$, ${}_n L_x^{-i}$, ${}_n T_x^{-i}$ and ${}_n e_x^{-i}$ are calculated as conventional life table.

Decomposition of life expectancy at birth difference

When a specific cause is eliminated from the decrement process, there has been change in the mortality in the all age groups that can be lead to gain or loss in the life expectancy. The difference in the life expectancy at birth with the presence and absence of the specific cause i.e. gain at birth can be decomposed into specific age groups to determine which age groups probably most contributed to the total gain using the procedure proposed by Arrianga, 1984.

$$ {}_n DLE_x = \frac{l_x}{l_0} \left(\frac{{}_n L_x^{-i}}{l_x^{-i}} - \frac{{}_n L_x}{l_x} \right) + \frac{T_{x+n}^{-i}}{l_0} \left(\frac{l_x}{l_x^{-i}} - \frac{l_{x+n}}{l_{x+n}^{-i}} \right) \qquad (19) $$

The first term at the right side of the equation refers to the direct effect of a change in mortality rates between ages x and x + n that consequence to change in the life years within the specific age group, whereas the second term refers to the sum of both the indirect and interaction effects of contributions resulting from the number of person-years to be added because of additional survivors at age x + n exposed to the new mortality conditions. The equation used for the open-ended interval is as follows

$$ {}_\infty DLE_x = \frac{l_x}{l_0} \left(\frac{T_x^{-i}}{l_x^{-i}} - \frac{T_x}{l_x} \right) \qquad (20) $$

Results and Discussion

Table 1 indicates the construction of conventional abridge life table of India in 2015 where assumption is made that mortality (All causes combined) is the only way of exiting from the cohort. Results show that infant mortality rate is about 42 deaths per 1000 babies, lower mortality rate from 15-44 age groups and rapidly increased above 45 ages. The probability of dying is high in the under-five ages and older age group. In the cohort, 40 deaths per 1000 live births observed. Using to GBD, 2015 data, the computed life expectancy at birth is 67.3 years. As per Sample Registration System (SRS), the life expectancy at birth in India is 67.9 years for the period 2011-2015.

Table 2a, 2b and 2c represents that multiple decrement life tables of India, 2015. According to the Table 1, the probability of dying of a person who alive at age 15 will die before reaching age 65 is 0.2009 $\left(\frac{l_{15}-l_{65}}{l_{65}}\right)$. The probability of eventually dying from HIV/AIDS is increased from the age 25, reached its peak at the age interval 40-44 years and after declined gradually in the presence of all other causes. In case of TB, probability of dying is gradually increased as in other hand age is increased. Probability of eventually dying from IID, LRI and Diarrheal disease is higher in under 15 and above 70 years of age. In case of malaria also probability is increasing as age increased.

From Table 2a, observed that proportion of new born babies that will at last die from HIV/AIDS under the India's age-cause specific mortality rate of 2015 is 0.87%. This is very minimal portion of deaths due to HIV/AIDS. The proportion of new born babies that will eventually die from the TB, IID, Malaria, LRI and Diarrheal disease respectively from hypothetical cohort of 100000 live births is approximately 4%, 0.45%, 0.48%, 5% and 5% (See Table 2a & 2b).

Table 1 Conventional Abridge life table of India, 2015

Age group	$_nN_x$	$_nD_x$	$_nm_x$	$_na_x$	$_nq_x$	l_x	$_nd_x$	$_nL_x$	$_nT_x$	e_x^0
0	24928421	1043746	0.0419	0.1638	0.0405	100000	4045	96617	6732962	67.33
1	99287448	219352	0.0022	1.5822	0.0088	95955	843	381779	6636345	69.16
5	127010192	104808	0.0008	2.2223	0.0041	95111	392	474469	6254566	65.76
10	126781840	86225	0.0007	2.6299	0.0034	94720	322	472836	5780097	61.02
15	123347960	155155	0.0013	2.6946	0.0063	94398	592	470626	5307261	56.22
20	118192144	221337	0.0019	2.6026	0.0093	93806	874	466934	4836635	51.56
25	112815304	249642	0.0022	2.5642	0.0110	92932	1023	462167	4369701	47.02
30	104214856	271468	0.0026	2.5934	0.0129	91909	1190	456682	3907534	42.52
35	91289312	315749	0.0035	2.6010	0.0172	90719	1556	449864	3450851	38.04
40	81019496	357006	0.0044	2.6239	0.0218	89163	1944	441198	3000987	33.66
45	71118672	448829	0.0063	2.6368	0.0311	87219	2712	429688	2559790	29.35
50	62295828	560842	0.0090	2.6474	0.0441	84508	3725	413774	2130101	25.21
55	52777216	721214	0.0137	2.6521	0.0662	80782	5348	391356	1716327	21.25
60	42922776	911911	0.0212	2.6413	0.1012	75434	7631	359173	1324972	17.56
65	29038532	973549	0.0335	2.6081	0.1552	67804	10522	313851	965799	14.24
70	20109264	1035128	0.0515	2.5541	0.2286	57281	13094	254380	651948	11.38
75	13195170	967811	0.0733	2.7570	0.3149	44187	13915	189723	397568	9.00
80 +	11287075	1643920	0.1456	-	1.0000	30272	30272	207845	207845	6.87

Source: *GBD, 2015 and author's computations*

Table 2a Multiple Decrement life table for HIV/AIDS, TB, IID, India, 2015.

Age group	Cause: HIV/AIDS				Cause: Tuberculosis				Cause: IID			
	$_nD_x^i$	$_nq_x^i$	$_nd_x^i$	l_x^i	$_nD_x^i$	$_nq_x^i$	$_nd_x^i$	l_x^i	$_nD_x^i$	$_nq_x^i$	$_nd_x^i$	l_x^i
0	6310	0.0002	24	867	1904	0.0001	7	3967	4507	0.0002	17	453
1	1398	0.0001	5	843	3433	0.0001	13	3959	19443	0.0008	75	436
5	2798	0.0001	10	837	1885	0.0001	7	3946	21263	0.0008	79	361
10	4569	0.0002	17	827	2080	0.0001	8	3939	14989	0.0006	56	282
15	3800	0.0002	14	810	5644	0.0002	22	3931	9763	0.0004	37	226
20	5298	0.0002	21	795	12807	0.0005	51	3910	6185	0.0003	24	188
25	13181	0.0006	54	775	18488	0.0008	76	3859	4551	0.0002	19	164
30	20457	0.0010	90	721	22894	0.0011	100	3783	3485	0.0002	15	145
35	25180	0.0014	124	631	30090	0.0016	148	3683	2947	0.0002	15	130
40	24751	0.0015	135	507	32269	0.0020	176	3535	2550	0.0002	14	116
45	19246	0.0013	116	372	41811	0.0029	253	3359	2235	0.0002	14	102
50	13210	0.0010	88	256	44183	0.0035	293	3106	1909	0.0002	13	88
55	7718	0.0007	57	168	49312	0.0045	366	2813	1540	0.0001	11	75
60	4735	0.0005	40	111	52232	0.0058	437	2447	1402	0.0002	12	64
65	2620	0.0004	28	71	43916	0.0070	475	2010	1198	0.0002	13	52
70	1671	0.0004	21	43	43875	0.0097	555	1535	992	0.0002	13	39
75	982	0.0003	14	22	30881	0.0100	444	980	753	0.0002	11	27
80 +	412	0.0003	8	8	29133	0.0177	536	536	870	0.0005	16	16

Overall these six infectious diseases accounted the approximately 15% of deaths of the hypothetical cohort of the 100000 live births and other infectious diseases accounted for only approximately 6% in the infant stage (See Table 2c). In the older age 74-79 and 80 above, proportion of persons living in the age group 74-79 and 80 above who eventually die from LRI and diarrheal disease is 5 and 6% respectively. Remaining infectious diseases accounted less than 1% of proportion in the older age groups.

To estimate the probability of dying between the two birthdays, differencing deaths between the two birthdays of a specific cause and also total deaths by all causes, the ratio gives the required probability. By estimating this probability, one can answer that which specific cause has highest probability in the specific age range. Probability of dying under 15 years of age i.e. probability of dying of new born babies before attaining age 15 from specified causes like HIV/AIDS, TB, IID, Malaria, LRI and Diarrheal disease respectively 0.0102, 0.0063, 0.0406, 0.0092, 0.1087 and 0.0845.

These figures show that for persons in the age range 0-15, the most likely cause of deaths among these diseases is LRI fallowed by Diarrheal disease. When comparison made between the six diseases combined and other infectious diseases, chance of dying between the age range 0-15 years due to the other infectious diseases (0.5729) is almost twice than the six infectious diseases combined (0.2596) (See Table 2C). Likewise, probability of dying in the age range 15-60 years due to HIV/AIDS, TB, IID, Malaria, LRI and Diarrheal disease respectively is 0.0369, 0.0782, 0.008, 0.0118, 0.0351 and 0.0332. Cause of death over the age range 15-60 is TB fallowed by the HIV/AIDS. Adult mortality i.e. 15-60 age range, chance of dying between the age range 15-60 years due to the six infectious diseases combined (0.2038) is almost four times of other infectious diseases (0.0511).

Fig 2 represents the probability of dying of a person living in the age interval $(x, x+n)$ in the absence of HIV/AIDS, TB, IID, Malaria, LRI and Diarrheal disease respectively. Elimination of a specific cause can answer the questions like, whether probability of dying is decreased when specific cause elimination is made or for which specific cause elimination can reduce more probability of dying of a person living in the age interval $(x, x+n)$. We observed that reduction in the probability of dying in the all the age interval $(x, x+n)$ when each cause eliminated separately. When all causes are considered, the probability of dying at infant stage is 0.0405 that reduced to 0.0402, 0.0404, 0.0403, 0.0404, 0.0367 and 0.0377 when HIV/AIDS, TB, IID, Malaria, LRI and Diarrheal disease eliminated respectively.

Table 2b Multiple Decrement life table for Malaria, LRI and Diarrheal disease

Age group	Cause: Malaria				Cause: LRI				Cause: Diarrheal disease			
	${}_nD^i_x$	${}_nq^i_x$	${}_nd^i_x$	l^i_x	${}_nD^i_x$	${}_nq^i_x$	${}_nd^i_x$	l^i_x	${}_nD^i_x$	${}_nq^i_x$	${}_nd^i_x$	l^i_x
0	2339	0.0001	9	467	99125	0.0038	384	4889	72919	0.0028	283	4712
1	4945	0.0002	19	458	41524	0.0017	160	4505	31724	0.0013	122	4429
5	3450	0.0001	13	439	10756	0.0004	40	4345	11908	0.0005	44	4307
10	2835	0.0001	11	426	6663	0.0003	25	4305	6553	0.0003	24	4263
15	3644	0.0001	14	416	8340	0.0003	32	4280	7904	0.0003	30	4238
20	3368	0.0001	13	402	9619	0.0004	38	4249	9083	0.0004	36	4208
25	3520	0.0002	14	389	9638	0.0004	39	4211	8940	0.0004	37	4172
30	3145	0.0001	14	374	9912	0.0005	43	4171	8990	0.0004	39	4136
35	4232	0.0002	21	360	11219	0.0006	55	4128	10114	0.0005	50	4096
40	3790	0.0002	21	340	12411	0.0008	68	4072	10097	0.0006	55	4046
45	6541	0.0005	40	319	14757	0.0010	89	4005	14170	0.0010	86	3992
50	6050	0.0005	40	279	18371	0.0014	122	3916	16092	0.0013	107	3906
55	6261	0.0006	46	239	24258	0.0022	180	3794	25791	0.0024	191	3799
60	5231	0.0006	44	193	32252	0.0036	270	3614	33679	0.0037	282	3608
65	3924	0.0006	42	149	36314	0.0058	392	3344	39828	0.0063	430	3326
70	3848	0.0008	49	107	43829	0.0097	554	2951	46023	0.0102	582	2895
75	1965	0.0006	28	58	46681	0.0152	671	2397	43619	0.0142	627	2313
80 +	1614	0.0010	30	30	93714	0.0570	1726	1726	91565	0.0557	1686	1686

Table 2c Multiple Decrement life table for six diseases combined and other Infectious diseases

Cause: Six IDs combined				Cause: Other IDs			
${}_nD_x^i$	${}_nq_x^i$	${}_nd_x^i$	l_x^i	${}_nD_x^i$	${}_nq_x^i$	${}_nd_x^i$	l_x^i
187104	0.0073	725	15356	741393	0.0287	2873	5855
102468	0.0041	394	14630	57887	0.0023	223	2981
52060	0.0020	194	14236	17922	0.0007	67	2759
37690	0.0015	141	14042	12494	0.0005	47	2692
39096	0.0016	149	13901	19453	0.0008	74	2645
46360	0.0020	183	13752	29432	0.0012	116	2571
58317	0.0026	239	13569	26746	0.0012	110	2455
68882	0.0033	302	13330	23422	0.0011	103	2345
83781	0.0046	413	13028	20759	0.0011	102	2242
85868	0.0052	468	12615	17480	0.0011	95	2140
98760	0.0068	597	12148	17069	0.0012	103	2045
99814	0.0078	663	11551	16792	0.0013	112	1942
114879	0.0105	852	10888	20881	0.0019	155	1830
129531	0.0144	1084	10036	23416	0.0026	196	1675
127801	0.0204	1381	8952	24288	0.0039	263	1479
140237	0.0310	1774	7571	25103	0.0055	318	1217
124880	0.0406	1796	5797	21266	0.0069	306	899
217309	0.1322	4002	4002	32236	0.0196	594	594

Under the 24 mortality is tremendously declined compared to the cause eliminated that are HIV/AIDS, TB, IID and malaria when LRI and Diarrheal disease eliminated. Mainly for under 5 mortality LRI and Diarrheal diseases are major cause of deaths in India. According from GBD 2017 estimates, Diarrheal disease and LRI stand top 4 and 5 cause of death for especially child mortality in India respectively. So, eliminating these diseases can boost up the life expectancy at birth. But age range 25-49 mortality, maximum reduction in probabilities when TB and HIV/AIDS eliminated. Older than 50 mortality can reduce by eliminated the diseases like TB, LRI, Diarrheal disease and Malaria also.

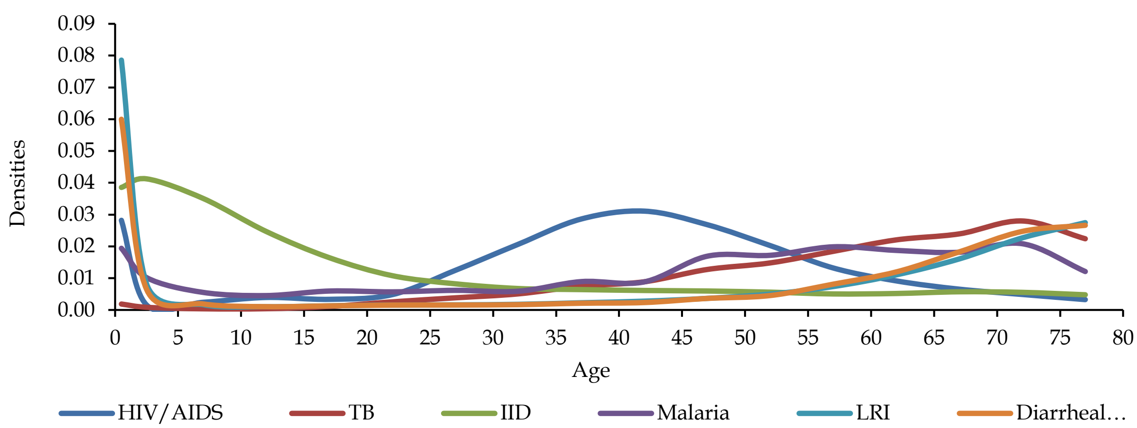

Figure 1 Density of cause of deaths

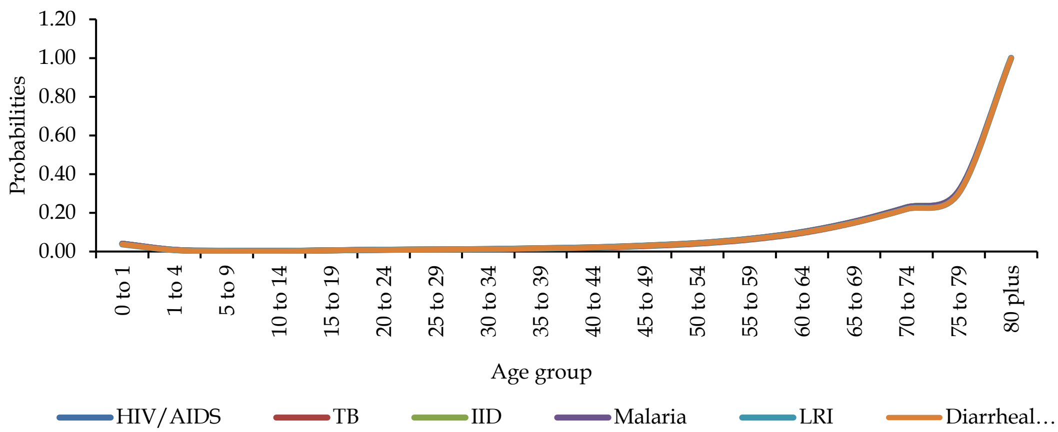

Figure 2 Probability of dying in the age interval $(x, x+n)$ in the absence of Specific cause

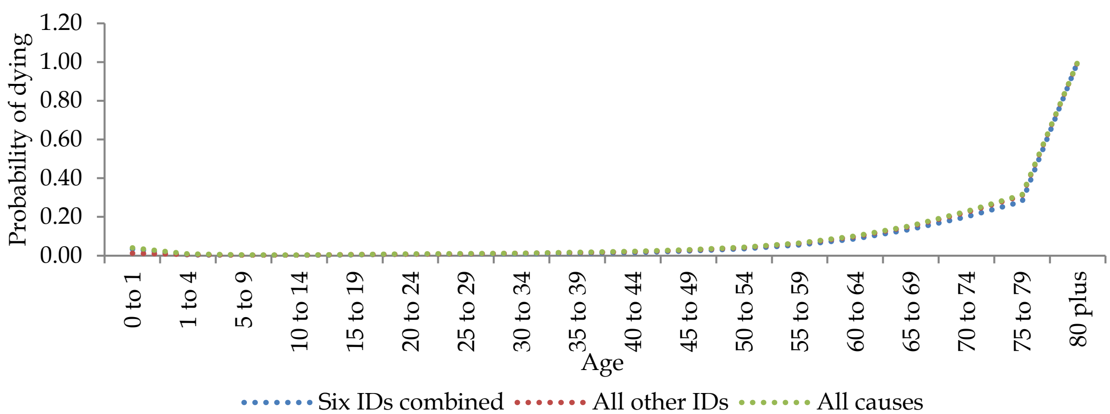

Figure 3 Probability of dying in the age interval $(x, x+n)$ in the absence of Six IDs combined and all other IDs combined.

It is observed that for all causes combined probability of dying between the age 0 and 15 is 0.056 and when LRI alone eliminated the probability is reduced to 0.050, if Diarrheal disease alone eliminated then probability is reduced to 0.0514. The probability of dying between the age 15 and 60 for all causes combined is 0.2008 is reduced to 0.1868 and 0.1944 when TB alone and HIV/AIDS alone eliminated respectively.

Probability of dying in the age interval $(x, x+n)$ comparatively reduced when six IDs together eliminated than the all other IDs combined elimination except 0-1-year age group (See Fig 3). Table 3 gives the life expectancy of at age x when these specific causes eliminated separately. Life expectancy at birth is 67.33 years in the presence of all causes. Each cause alone eliminated which are considered for study and observed that approximately one-year gain in the life expectancy at birth when LRI is eliminated.

Similarly, Diarrheal disease alone and TB alone eliminated then 0.85 and 0.72 years gain in the life expectancy. Also checked the absence of six IDs combined and all other IDs combined separately to know the more gain in the life expectancy at birth. There is 3.31 years increased at birth in the absence of six IDs combined whereas 2.75 years increased at birth when all other IDs together eliminated. These can be indicating the severity of these six IDs among the all IDs.

To know which age group contributes more to the gain in the life expectancy at birth after elimination of six IDs together, we decomposed the total difference (3.31 years) to the specific age group. It is observed that 0-1 and 1-4 age groups contribute approximately 16 and 8% of total difference to the improvement in the life expectancy when mortality of six IDs together eradicated. Above 80 also contribute approximately 9% of the total difference.

Table 4 gives decomposition of additional life years gained by eliminating the six ID's. Arriaga's decomposition method allows for the breakdown of differences in life expectancy into age groups (Eq 19 & 20) facilitating an understanding of life expectancy variations by identifying the contribution of each factor. Within the additional 3.31 years, 0.52 years contributed to 0 to 1 age group and 0.28 years contributed to 1 to 4 age group. That indicates approximately one fourth of additional life year contributed to under five age group.

Table 3 Life expectancy at age x, India, 2015

Age group	e_x^0	e_x^{-HIV}	e_x^{-TB}	e_x^{-IID}	$e_x^{-Malaria}$	e_x^{-LRI}	$e_x^{-Diarrheal}$	$e_x^{-SixIDs}$	$e_x^{-All other IDs}$
0 to 1	67.33	67.61	68.05	67.55	67.45	68.28	68.18	70.64	70.08
1 to 4	69.16	69.44	69.91	69.38	69.28	69.88	69.84	72.07	69.92
5 to 9	65.76	66.03	66.50	65.92	65.87	66.37	66.36	68.40	66.37
10 to 14	61.02	61.29	61.76	61.13	61.13	61.61	61.59	63.54	61.59
15 to 19	56.22	56.48	56.96	56.30	56.32	56.79	56.78	58.66	56.76
20 to 24	51.56	51.81	52.29	51.62	51.65	52.11	52.10	53.92	52.06
25 to 29	47.02	47.26	47.73	47.06	47.10	47.56	47.55	49.30	47.46
30 to 34	42.52	42.73	43.20	42.55	42.59	43.04	43.03	44.70	42.90
35 to 39	38.04	38.22	38.68	38.07	38.11	38.55	38.55	40.11	38.39
40 to 44	33.66	33.79	34.25	33.68	33.72	34.16	34.15	35.59	33.97
45 to 49	29.35	29.44	29.89	29.37	29.41	29.83	29.84	31.15	29.63
50 to 54	25.21	25.26	25.69	25.22	25.25	25.68	25.68	26.86	25.47
55 to 59	21.25	21.28	21.66	21.26	21.28	21.70	21.71	22.77	21.49
60 to 64	17.56	17.58	17.91	17.57	17.59	18.01	18.01	18.96	17.78
65 to 69	14.24	14.26	14.53	14.25	14.27	14.67	14.67	15.53	14.44
70 to 74	11.38	11.39	11.61	11.39	11.40	11.80	11.79	12.56	11.55
75 to 79	9.00	9.00	9.16	9.00	9.01	9.41	9.39	10.08	9.15
80 plus	6.87	6.87	6.99	6.87	6.87	7.28	7.27	7.91	7.00

Table 4 Decomposition of additional life years at birth

Age	l_x	${}_nL_x$	${}_nT_x$	$l_x^{(-i)}$	${}_nL_x^{-i}$	${}_nT_x^{-i}$	Change	Percent
0 to 1	100000	96617	6732962	100000	97224	7064120	0.52	15.70
1 to 4	95955	381779	6636345	96668	385576	6966897	0.28	8.41
5 to 9	95111	474469	6254566	96214	480516	6581321	0.13	3.89
10 to 14	94720	472836	5780097	96014	479665	6100805	0.09	2.60
15 to 19	94398	470626	5307261	95831	478137	5621140	0.08	2.53
20 to 24	93806	466934	4836635	95381	475218	5143003	0.09	2.85
25 to 29	92932	462167	4369701	94677	471430	4667785	0.11	3.38
30 to 34	91909	456682	3907534	93878	467196	4196355	0.13	3.85
35 to 39	90719	449864	3450851	92969	462040	3729159	0.16	4.71
40 to 44	89163	441198	3000987	91795	455379	3267119	0.16	4.70
45 to 49	87219	429688	2559790	90271	446214	2811739	0.17	5.22
50 to 54	84508	413774	2130101	88075	432894	2365525	0.16	4.95
55 to 59	80782	391356	1716327	84870	413271	1932631	0.18	5.35
60 to 64	75434	359173	1324972	80121	384178	1519360	0.19	5.62
65 to 69	67804	313851	965799	73116	341853	1135182	0.19	5.82
70 to 74	57281	254380	651948	63152	284901	793329	0.20	6.03
75 to 79	44187	189723	397568	50459	221251	508428	0.16	4.83
80 plus	30272	207845	207845	36297	287178	287178	0.32	9.56

Conclusion

We considered these six IDs because severity of these six IDs is more among the all IDs. Idea is to know the change in life expectancy at birth when each cause (disease) alone eliminated from the decrement process using the associate single decrement life table. There is a gain in the life expectancy at every age when each cause alone eliminated but not greater than one year. This may because of low magnitude of infectious diseases mortality data. Among these six IDs, LRI seems to be more serious because more gain in the life expectancy when LRI is eliminated.

When all the selected six IDs are eliminated the gain in the life expectancy is 3.31 years and when all the IDs excluding selected IDs are eliminated the life expectancy is decreased by approximately seven months as compared to elimination of six IDs. Hence elimination of six IDs together gives more additional years to live at the birth. These additional years is decomposed for specific age groups and conclude that under five age group contribute the more improvement in the gain in life expectancy. The government of India has to make a policy for controlling these six IDs to increase the life expectancy of Indian people.

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