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Should life potential be a better alternative to life expectancy at birth? an Indian illustration

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Abstract

Given the limitation of life expectancy at birth as an indicator of survival as regard its comparison across population and over time, life potential per capita is suggested as an alternative to overcome such limitation. An illustration of this alternative indicator in case of Indian states presents a case for consideration as it makes a robust comparison of survival well being with consideration of the age structure of the population and the prevailing regime of survival.

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1. Introduction

The most popular indicator of health, well being and survival is the life expectancy at birth. This is an indicator which summarises the survival experience of a population corresponding to a period age schedule of mortality. Although this summary measure has a clear interpretation as the average expected years of life at birth provided an individual experiences a given age-schedule of mortality, it does not represent any typical individual in the population. In a given population each individual represents a birth cohort and experiences the evolving mortality risk which varies from time to time. Therefore summarising mortality experience involves the period as well as cohort impact within it. Despite this limitation, life expectancy has gained the popularity of a simple measure of population health (Murray et.al 2002) due to its interpretative strength and population connotation. It describes a population's survival over a time period although it does not have any individual quotient whatsoever. It means that we cannot describe the life expectancy for individuals rather than it can only be done only for a population. The limitation in comparison of life expectancy over time and across population is well documented (Chakraborty and Mishra, 2003; Mishra, 2004, 2011) When we compare it across populations there arises a concern as to whether a higher life expectancy is to be rated positively against a lower life expectancy irrespective of the age structure of the population. Further, are gains in life expectancy shared equally by various birth cohorts within a population? Apart from these concerns, life expectancy as an indicator of survival does not maintain consistency with alternative indicators of survival. For instance, if we consider a range of alternative survival indicators like death rates, infant mortality rates, adult mortality rate, median age at death and proportions surviving till a certain age, there is a mismatch in rank between life expectancy and these indicators except for infant mortality which is sensitive to changes in life expectancy. This disqualifies the expectation of life at birth as a robust indicator with respect to the criterion of order dominance.

Robustness of this indicator in particular is desirable given its wide spread use as an indicator of survival and well being. An indicator of this kind is not prone to quick changes unless otherwise when the mortality regime undergoes drastic changes. Improvement and deterioration in this indicator is conditioned more by the changes in mortality in early years of life than later years. This distortion to the indicator is inherent in its construct and conceptualization which implies that progress in the indicator is concave. However, the users of this indicator hardly recognise these limitations and tend to make comparisons of this indicator across situations and in terms of the quantum improvement in it. Improvement in life expectancy can very well depend upon the base from where improvement is to be attained on one hand and the population's structure that it represents on the other.

Interpretation of life expectancy is based on the fundamental premise- the higher the better. However this premise can be interrogated on three counts. Firstly, can two populations who have equal gains in life expectancy but varying age structure be treated as equal? Secondly, as gains in life expectancy are conditional upon the age structure of the population, would it not be easier for younger population to gain then the older ones? In that case, can equal gains in population that are younger and older be treated equal? Thirdly, for this reason should not the connotation of a certain level of life expectancy then be conditional upon the age attribute of the population as young or old? In order to overcome these problems in comparing life expectancy, we attempt to illustrate an alternative indicator `life potential per capita; this concept emerges out of the observation that the life expectancy as an indicator has a distribution of its own over age. It is lower at the higher ages and vice versa. Therefore the life expectancy that only considers the propensity of survival across age partially describes the survival experience of a population. This can be adjusted by taking the distribution of life expectancy across ages by weighing the survival potential by the distribution of population across these ages.

2. Life potential: an alternative Indicator to Life Expectancy

A survival indicator like the life expectancy summarises the experience of a population which will consist of individuals at different stages of life. Any alternative to this, in view of the limitations outlined earlier has to enable status comparison as well as incorporate within the indicator, a potential to compare relative prospects for improvement in that status. Currently, the life expectancy takes into account the years survived and the expected years of survival. The limitation of this is that it does not take into account the current age structure of the population and therefore does not distinguish between the differentials in potential for improvements in the status. Any alternative that does so will have to aggregate years survived and the perspective years of life adjusting for the age structure of the population. The indicator proposed by Goerlich and Soler (2011) `the life potential per capita fulfils this requirement. This alternative demographic indicator suggested by Goerlich and Soler (2011) will facilitate comparisons across societies with varying longevity. The authors proposed this index as a measure that would be decomposed in terms of changes in survival due to period (i.e. time) and changes in the demographic (i.e. the population structure). We in this paper reiterate this indicator's relevance in capturing the second component `demographics'. By incorporating within its conceptualization this aspect, the `life potential per capita' accommodates the differences in age structure, thus being an improvement over life expectancy on that count.

3. Measuring Life potential

To compute the life potential per capita, we need the population classified by age and sex and their corresponding life expectancies. Goerlich and Soler (2011) define life potential for a given individual at age `x' as their life expectancy given their current age and life potential for a society.

L is the aggregation over individual life potential

$$L = \int_0^\infty P(x)e(x)dx \tag{1}$$

Where P(x) is the population at age `x' and e(x) is the corresponding life expectancy. This L becomes weighted sum of life expectancies at different ages. When countries have different population sizes, it becomes difficult to compare the life potential for a society. This limitation can be overcome by using the life potential per-capita; l thus

$$l = \frac{L}{P} = \int_0^\infty w(x)e(x)dx \tag{2}$$

Where P is the total population

$P = \int_0^\infty p(x)dx$ and $w(x) = \frac{P(x)}{P}$ Such that $\int_0^\infty w(x)dx = 1$

Thus the life potential per capita has been described as a weighted average of life expectancies where the weights are given by population shares. This measure `l' increases in life expectancy at any age and decreasing in population aging. Thus life potential per capita at any given age can be treated as the life expectancy of a given population where as the expectation of life at any given age is the life expectancy of the cohort at the given age.

The discrete case for equation 2 would then be

$$l = \sum_{0}^{110+} w(x)e(x) \tag{3}$$

$e(x) = 1/2(ex + e(x+1))$ and w(x) =Px/P where $P = \sum_{x \geq 0} px$ and px is the population in the age interval (x, x+1) at a given point in time. This population share is computed using the age structure of the population provided by the sample registration system based data pertaining to the year 2010 for the illustration made below.

Hence the changes in life potential per capita between two points in time can be decomposed into changes due to the demographic structure and changes in survival experience ex. Decomposition of this component i.e. the age structure makes it possible to identify the potential for improvements.

4. Illustration: Life potential for India and its states

We have computed the life potential for the Indian states to facilitate a comparison with the life expectancy at birth. The life expectancy at birth for the states ranged between 62-74 years. The median age for the states ranged between 20 and 32 years indicating the youngness and oldness of the population. The rank order correlation between life expectancy and life potential per-capita was very small in magnitude indicating that the two do not co-vary. When the life expectancy and life potential per capita were ranked with median age, we find that relatively older populations have higher life expectancy. Other things remaining constant, younger populations with higher life expectancy will produce greater welfare than an older population with higher life expectancy. Examining the states in terms of the life expectancy at birth and life potential per-capita, we find that states with higher life expectancy do not necessarily have greater life potential per-capita. This is because life potential per-capita is conditioned by the age structure of the population. In fact the life potential per-capita varies less across the states when compared to the life expectancy at birth (CV=0.03 and 0.05).

The moderation in the values of life potential per-capita is the resultant of weighing the life expectancies at different ages by the proportional share of population at that age. To depict the extent of variation in the two indicators, we calculated the normalized values and found that the association between the two in terms of correlation was weak (r=-0.028, p=0.921).

Reading the computed values of life potential per-capita against the life expectancy at birth for the states of India, one finds that Karnataka and Kerala have almost the same life potential but their life expectancy differ by 7 years. Similarly, Gujarat, Madhya Pradesh and West Bengal have more or less similar life potential per-capita while their life expectancy varies between 62.4 to 69 years. On the other hand, states like Haryana and Karnataka have similar life expectancy (67.0 and 67.2 years) but their life potential per-capita varies from 43.63 years to 46.79 years respectively. There are states like Rajasthan and Punjab where life potential per capita and life expectancy seem to be inversely related. Punjab has a high life expectancy (69.3 years) and a lower life potential (45.26) whereas Rajasthan has a lower life expectancy (66.5 years) but a higher life potential i.e. 48.05.

The life potential per capita is therefore a more robust indicator of survivorship and aging when compared to life expectancy. An examination of the ranks for the two indicators reveals the extreme reversals that are possible- viz. the state of Kerala which has a rank of 1 with respect to life expectancy and a rank of 10 in terms of life potential per-capita. In order to gauge the variation in the values both the life expectancy and the life potential per capita have been normalized using their respective range of variation. The normalized values ranged between 0 and 1. The correlation between these two is -0.0282(p=0.921) indicating that the association between the two is weak. We therefore suggest that the life potential per-capita has advantages over the life expectancy because it weighs the years of life by the proportion of people who live them. This new measure of survival is valid at an individual level as well as at population level which enables comparison across varying population structures. The rank order correlation between these two factors, the median age of the population and the life potential per capita is significant (R=-0.639, p=0.010)

5. Conclusion

This illustration demonstrates the relative robustness of the life potential per capita as an indicator of survival compared to the life expectancy. It accommodates the age structure in its computation and represents the population's potential for improving its survivorship. Its relative advantage over the life expectancy is that it renders individual welfare comparison possible where as life expectancy facilitates welfare comparison only population or groups.

Table 1: Life Expectancy at Birth and Life potential per capita for Indian States, 2010

State	Life Expectancy at Birth	Rank of life Expectancy	Life Potential per capita	Rank of Life Potential per capita	Normal Life Expectancy at Birth	Normal Life Potential per capita	Median Age in 2010	Rank of Median Age 2010
Andhra Pradesh	65.8	10	42.55	14	0.32	0.07	27.15	3
Assam	61.9	15	43.2	12	0	0.18	23.63	11
Bihar	65.8	11	47.65	2	0.32	0.93	20.17	15
Gujarat	66.8	8	44.93	6	0.4	0.47	25.8	9
Haryana	67.0	7	46.79	3	0.41	0.79	23.85	10
Karnataka	67.2	6	43.63	11	0.43	0.25	26.72	6
Kerala	74.2	1	43.78	10	1	0.28	31.62	1
Madhya Pradesh	62.4	14	44.72	8	0.04	0.44	22.82	12
Maharashtra	69.9	2	44.75	7	0.65	0.44	26.8	5
Odisha	63.0	12	42.8	13	0.09	0.11	25.97	8
Punjab	69.3	3	45.26	5	0.6	0.53	26.83	4
Rajasthan	66.5	9	48.05	1	0.37	1	22.58	13
Tamil Nadu	68.9	5	42.13	15	0.57	0	29.7	2
Uttar Pradesh	62.7	13	45.69	4	0.07	0.6	21.36	14
West Bengal	69.0	4	44.63	9	0.58	0.42	26.63	7

Source: Life Expectancy from Sample Registration System (2012) and Life Potential is Author's own Calculation, Median Age from the Population Projection 2006-26 (2006)

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