RESEARCH COMMUNICATION

# An Indirect Study of Cancer Survival in the Context of Developing Countries

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## Abstract

**With classical approaches, survival refers to the life of a person after diagnosis of disease, and survival studies deal with measurement of the same to evaluate overall performance of a group of patients in terms of quality and quantity of life after diagnosis/treatment. There are numerous difficulties in the conduct of a population-based survival study in the context of developing countries, including India. Loss to follow-up is a typical problem encountered, causing biased estimates. In view of this difficulty with the classical approach, the objective of this study was to propose an indirect methodology for the study of survival. Proposed methodology is based on life table techniques and uses current data on incidence and mortality from the disease. It involves the estimation of person years free of disease (PYFD), person years with disease (PYWD), person years of life lost (PYLL) and average duration of disease (ADD) and their comparison over a time period. Empirical application was carried out for mouth and lung cancers in males and cancers of breast and cervix in females as well as for all sites combined together in each sex. Cancer incidence and mortality data by age and sex for the years 1989, 1993, 1997 and 2001 were obtained from published reports of Mumbai Cancer Registry, India. All causes of deaths for these years were obtained from Mumbai Municipal Corporation. Three life tables were constructed by applying various attrition factors: (a) risk of death from all causes; (b) risk of incidence and that of death from other causes; and (c) risk of death from other causes only. The expectation of life from the second life table gave PYFD. PYWD and PYLL were calculated by suitable subtractions among three expectations of life. ADD was calculated by dividing person years lived with disease by number developing the disease. It was noted that during 1993-2001, PYFD for all sites increased from 59.4 to 62.1 and from 63.8 to 66 years in males and females respectively. PYLL was about 0.8 year in males and 1 year in females. Similarly, PYWD was 0.6 and 1 year in males and females. ADD for all sites varied from 4 to 4.7 years in both sexes. It was about 6 years for mouth cancers and 2 years for lung cancers in males and 4-5 years for breast and cervical cancers in females. Validation of the ADD was carried out by comparison with published data for calculating median duration of disease. Given the difficulties in conduct of classical survival studies, the proposed method may provide a useful tool for having a regular audit of prognostic factors in the community.**

**Key Words:** Indirect survival study - life table technique - average duration of disease - India - major cancers

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## Introduction

In classical approaches, survival refers to the life of a person after diagnosis of the disease, and the survival studies deal with the measurement of survival with the objective of evaluating the overall performance of a group of patients in terms of quality and quantity of life after the diagnosis or treatment. Population based survival studies collect data on vital status of the patients of a particular disease among the population of a predefined geographic area. After collection of data, actuarial and other techniques are applied to calculate the probability of survival over time period. These results are useful in evaluating the overall impact of the community based public health programmes. Population based survival can also be used in identifying the priority areas for public health policy planners and in quantifying the burden of a particular health problem in the population.

In other words, population based survival rates are useful measure for estimating the overall efficiency of the health system, which depends on the quality of patient's care, patient characteristics and availability of treatment. The ideal way of measuring a population based survival is to define a cohort of patients diagnosed with the disease, follow them till the cohort diminishes to zero and then calculate the average survival by the members of the cohort. This approach requires follow-up of cohort members for a long period of time, and this requirement

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makes conduct of a survival study quite difficult. Alternate common approach of population-based survival studies is to find the proportion of patients surviving a certain interval of time after diagnosis. There are numerous difficulties in the conduct of a population based survival study in the set up of developing countries including India. The difficulties start with the planning of a population based survival study and continue till the end of the study. While planning a population based survival study, one has to consider the possibility of a substantial amount of financial and other resources required including the time required. Subsequently, loss to follow-up is a typical problem encountered in survival studies. On the other hand it is believed that survival is inherent in morbidity and mortality data (Pollard, 1980).

In the present communication, we propose an indirect procedure for the study of survival in the context of developing countries. The methodology has been demonstrated empirically using data on cancer incidence and mortality from Mumbai, India. Specific objectives of the study were to a) suggest an indirect methodology for the study of survival, b) demonstrate an empirical application of the methodology and c) validate the suggested methodology.

## Materials and Methods

The proposed approach of survival study is based on the estimation of various components of life over a period of time using current data on (i) incidence and mortility due to the disease under consideration, (ii) mortality due to all causes in general population and (iii) age and sex wise distribution of population for Mumbai. In the present study, data on cancer has been utilized as the disease under consideration.

*Cancer incidence and mortality*

Data on occurrence of cancer incidence and mortality in the country are available from population based cancer registries (PBCRs) established in various parts of the country. Although several cancer registries are operating in the country, as opposed to cancer morbidity data, an authentic cancer mortality data is available from Mumbai and a few other registries only. However, cancer mortality data over a period of time is available from Mumbai registry only. The age sex and site-specific cancer incidence and mortality data for the years 1989, 1993, 1997 and 2001 were collected from respective published reports of Mumbai Cancer Registry (Jussawalla et al, 1991, 1995, 2000; Kurkure et al, 2005). Data collection methodologies and quality control methods for validating data have been described in the above reports.

*All causes mortality*

The present study employs the mortality data registered and compiled by Mumbai Municipal Corporation for the years 1989 (by broad age groups) (BMC, 1992), and 2001 (by 5-year age groups) (obtained by personal visit). Data for 1989 available by 10-year age groups were partitioned into 5-year age groups using proportions observed in 2001 within each broad age group. Subsequently, mortality data for the years 1993 and 1997 were estimated applying linear growth rate to the figures of each 5-year age group and sex in 1989 and 2001.

*Population*

Estimation of the Mumbai population for the years 1989, 1993 and 1997 required for present computations was done applying exponential rate of growth to mid-year population for the years 1991 and 2001 as reported by Mumbai Cancer Registry (Jussawalla et al, 1993; Kurkure et al, 2005).

*Methods*

Let us refer the expectation of life in presence of all the causes of death as `Real life' and the expectation of life in the assumed absence of a particular disease as `Imaginary life'. The imaginary life then can be divided into the real life and the expectation of life lost to the disease or in other words person years of life lost (PYLL). The real life can be further divided in to the expectation of life free of disease or in other words person years free of disease (PYFD) and the expectation of life with disease or in other words person years with disease (PYWD). Proposed methodology deals with the estimation of the length of these segments of life and the examination of changes therein over a period of time.

In order to estimate the length of various segments of life defined above, three life tables were constructed; (i) A general life table using all causes risk of death as the decrement factor, (ii) A multiple decrement life table using risk of selected disease incidence and the risk of death from all causes other than the one considered as the decrement factors, and (iii) A life table using risk of death from all causes other than the one considered as the decrement factor.

Let $P_i$, $CI_i$, $CD_i$ and $TD_i$ represent the population, cancer incidence, cancer death and deaths from all causes in the ith age group in terms of numbers. Then the deaths from all the causes other than cancer ($OD_i$) in ith age group is given by:

$$OD_i = TD_i - CD_i$$

The quantities $CI_i$, $CD_i$, $TD_i$ and $OD_i$ were converted to rates by dividing through the population $P_i$ and then converted to probabilities respectively $QCI_i$, $QCD_i$, $QTD_i$ and $QOD_i$ using the formula established by Greville (1943).

*Construction of life tables*

I. Life table with overall mortality as the decrement factor: This life table was constructed using established method suggested by Greville (1943). It is well known that a life table consists of various columns, like, number of persons at the beginning of age group x to x+n or radix column ($l_x$), probability of death in the age group ($_nq_x$), number dying in the age group ($_nd_x$), person years lived in the age group ($_nL_x$), person years lived in the age group and beyond ($T_x$) and the expectation of life ($e_x$). This life table was constructed by employing the general death rates as observed for Mumbai during various calendar years,

viz, 1989, 1993, 1997 and 2001. The expectation of life as obtained from this life table gave the length of real life defined earlier.

II. Multiple decrement life table with other mortality and disease incidence as the decrement factors: The present life table employed, viz, the risk of cancer incidence and the risk of death from other causes. The calculations of radix column ($l_x$), number developing cancer ($c_x$) and number dying from other causes ($d_x$) was done as follows under the assumption that the cohort was exposed to the risk of disease first and then to the risk of death from other causes.

For the first age group,

$l_1$= 100000 (Arbitrarily by convention)

$c_1 = l_1 * QCI_1$

$d_1 = (l_1-c_1) * QOD_1$

For the middle age groups,

$l_i = l_{i-1} – c_{i-1} – d_{i-1}$ i = 2,3,……...,n-1

$c_i = l_i * QCI_i$

$d_i = (l_i – c_i) * QOD_i$

For the last age group

$l_n = l_{n-1} – c_{n-1} – d_{n-1}$

Other columns of this life table were calculated by established methods assuming an even distribution of disease incidence and deaths from other causes in a particular age group. The expectation of life as obtained from this life table gave expectation of life free of disease, i.e., PYFD. The PYFD was subtracted from the length of real life to arrive at PYWD.

III. Life table with other mortality as the decrement factor: The main task in the construction of this life table was to find the number of deaths by age in the assumed absence of a cause of death considered. Once these numbers are obtained, we can derive the rate and probabilities followed by life table construction using established methods discussed earlier. There are many methodologies available in the literature to find the number of deaths in the assumed absence of a disease with their own merits and demerits. Although all the methods provide the numbers that are not statistically different (Namboodiri and Suchindran, 1989), we adopted the descriptive methodology proposed by Ram and Dhar (1992) due to simplicity and conceptual accuracy. In brief, this method is based on subtracting the number of persons died in a particular age group and subjecting them to the risk of death in the subsequent age groups in the assumed absence of considered disease. The expectation of life as obtained from this life table gave the length of imaginary life defined earlier. The length of real life was subtracted from imaginary life to arrive at PYLL.

*Calculation of ADD*

This was obtained by dividing the person years lived with cancer by the number developing cancer. To arrive at the number developing cancer, we need to know the break up of those surviving to the last age group ($l_n$) in second life table, who develop the disease and die ($c_n$) and who die without developing the disease ($d_n$). This has been done by iterating the quantity $l_n$ using projected values of the probability of developing the disease (QCI) and probability of dying from other causes (QOD). For the forward projection of QOD and QCI, regression lines of QOD and QCI were fit on n-1 age groups using least squares method and the intercepts and the regression coefficients were estimated using established formula.

*Validation*

Median duration of disease was estimated indirectly using survival rates from the published studies. Survival rates (percent surviving) for the intervals of 1, 3 and 5 years from various published studies dealing with the sites of cancer under study were compiled. Using these percent surviving 1, 3, and 5 years, percents deaths were prorated over the time, to arrive at the time interval by which fifty percent of the patients died. Thus median survival of the sites of cancer under study was estimated for different studies. These median survivals were compared with the ADD obtained from this study. Comparisons between different sites and over a time period according to the median survival and that according to ADD were compared. For all sites of cancer however, this validation was not possible as there is no visible study reporting the survival experience of all sites of cancer taken together.

## Results

*1. Proposed methodology*

i) Construct three life tables; general life table based on observed risk of mortality, multiple decrement life table using the risk of disease and the risk of death from other causes as the decrement factors and the life table using other causes of death as the decrement factor.

ii) Life tables make readily available the lengths of PYFD, real life and imaginary life. Calculate the survival indices like PYWD, PYLL and ADD.

iii) Examine these quantities and the changes therein over a period of time.

iv) Examine the rates of disease incidence and mortality and general mortality during the study period with main focus on stability/fluctuations.

v) Look at the potential prognostic factors and changes therein for possible explanations for the changes in the survival indices.

vi) Report the level of survival indices and changes therein along with possible explanations for the same.

*2. Empirical application*

2.1 Population by age and sex

The age and sex wise distribution of population during different calendar years under study is shown in Table 1. Total population of Mumbai in 1989 was estimated to be 5.2 million males and 4.3 million females, which grew at an annual exponential growth rate of respectively 2 and 1.9 percent to 6.6 and 5.4 million in 2001. During 1989 to 2001, a decrease in young age population (less than 30 years of age) and a corresponding increase in older population were noted in males. Proportion less than 25 years old decreased from 62.4 to 59.4 percent. Proportion

**Table 1. Total Populations and Percentage Age Distribution of the Population of Mumbai for the Four Calendar Years under Study**

| Age group | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | 1989 | 1993 | 1997 | 2001 | 1989 | 1993 | 1997 | 2001 |
| | 5,222,649 | 5,650,410 | 6,119,682 | 6,635,191 | 4,285,354 | 4,619,249 | 4,984,283 | 5,383,646 |
| 00-14 | 29.4 | 28.9 | 28.5 | 28.0 | 32.4 | 32.2 | 32.0 | 31.7 |
| 15-24 | 22.1 | 21.7 | 21.4 | 21.0 | 20.7 | 20.5 | 20.4 | 20.2 |
| 25-34 | 18.6 | 18.9 | 19.2 | 19.5 | 17.6 | 18.0 | 18.4 | 18.9 |
| 35-44 | 12.3 | 13.0 | 13.8 | 14.6 | 11.5 | 12 | 12.5 | 13.1 |
| 45-54 | 9.4 | 9.3 | 9.3 | 9.2 | 9.3 | 8.8 | 8.4 | 8.0 |
| 55-64 | 5.2 | 5.1 | 5.0 | 4.9 | 4.5 | 4.6 | 4.7 | 4.8 |
| 65+ | 3.1 | 3.0 | 2.9 | 2.8 | 4.0 | 3.8 | 3.5 | 3.3 |

**Table 2. Age Specific, Crude (CR) and Age-adjusted (AAR) Death Rates per 1,000 Person Years of Mumbai for the Four Calendar Years under Study**

| Age group | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | 1989 | 1993 | 1997 | 2001 | 1989 | 1993 | 1997 | 2001 |
| 00-14 | 5.8 | 4.8 | 3.9 | 3.1 | 6.0 | 4.8 | 3.8 | 2.9 |
| 15-24 | 2.1 | 2.1 | 2.0 | 1.9 | 2.2 | 2.1 | 1.9 | 1.8 |
| 25-34 | 3.9 | 4.0 | 4.1 | 4.1 | 2.5 | 2.4 | 2.3 | 2.1 |
| 35-44 | 7.6 | 7.6 | 7.4 | 7.2 | 3.8 | 3.6 | 3.3 | 3.1 |
| 45-54 | 12.6 | 12.5 | 12.4 | 12.2 | 5.7 | 5.9 | 6.0 | 6.2 |
| 55-64 | 22.6 | 22.9 | 23.0 | 23.1 | 15.7 | 15.1 | 14.4 | 13.7 |
| 65+ | 69.4 | 76.3 | 82.2 | 87.2 | 62.2 | 70.9 | 79.3 | 87.4 |
| CR | 8.3 | 8.2 | 8.0 | 7.8 | 7.0 | 6.7 | 6.4 | 6.1 |
| AAR | 12.0 | 12.1 | 12.2 | 12.3 | 9.4 | 9.5 | 9.6 | 9.8 |

of children decreased from 29.3 to 28 percent during the study period. Age distribution of the female population remained stable with little fluctuations.

2.2 Mortality

The age and sex specific deaths rates along with crude and age-adjusted rates for different calendar years from 1989 to 2001 have been shown in Table 2. As expected there was a decrease in crude death rate. Corresponding decrease however was not observed in the age-adjusted mortality rates.

2.3 Cancer incidence and mortality for selected sites

All sites: The incidence of cancers of all sites in terms of CIR declined whereas in females it increased. AAIR however, increased in both sexes (Table 3). The risk of cancer in childhood was less than 10 cases per 100,000 person years in both sexes with few exceptions in males especially in the age group 0-4. It was considerably higher among the persons 60 years or more in both sexes. Looking at the risk differentials by sex in 2001, it was observed that in the age group 15-64, women experienced a higher risk of cancer than men. Among children and senior citizen (65 years and above), the risk was higher in males.

CDR was slightly higher among females whereas AADR was lower, 61 deaths in females compared to 67 deaths per 100000 person years in males in 2001 (Table 3). Among the population aged less than 30 years of age, the risk of cancer death was less than 10 deaths per 100000 person years in both sexes. Sex differentials in the risk of cancer death in 2001 were somewhat similar to that in cancer incidence. It was higher in females in the age group of 35-59 years and in males in other age groups.

Mouth cancers in males: CIR increased during 1989-2001 (Table 3). Majority of mouth cancers occurred after the age of 45 years as the age specific rates before the age of 45 years were less than 10 cases per 100,000 person years. Looking at the age specific rates in 1989 and 2001, an increase was noted in all the age groups with the exception of the age group 35-39 years.

**Table 3. Crude (CIR) and Age-adjusted (AAIR) Cancer Incidence and Crude (CDR) and Age-adjusted (AADR) Cancer Death Rates per 100,000 Person Years of Mumbai for the Four Calendar Year under Study**

| Site of cancer | | 1989 | 1993 | 1997 | 2001 |
|---|---|---|---|---|---|
| Males | | | | | |
| All sites | CIR | 70.7 | 70.4 | 68.4 | 67.9 |
| | AAIR | 108.8 | 112.6 | 113.0 | 115.9 |
| | CDR | 36.0 | 37.5 | 36.8 | 35.8 |
| | AADR | 59.4 | 63.9 | 63.8 | 66.6 |
| Mouth | CIR | 3.5 | 3.9 | 3.5 | 5.1 |
| | AAIR | 5.1 | 5.7 | 5.3 | 7.7 |
| | CDR | 0.8 | 1.0 | 1.3 | 1.3 |
| | AADR | 1.2 | 1.6 | 1.9 | 2.0 |
| Lung | CIR | 7.2 | 6.4 | 6.3 | 5.6 |
| | AAIR | 12.0 | 11.3 | 11.5 | 10.7 |
| | CDR | 5.1 | 4.5 | 4.6 | 3.6 |
| | AADR | 8.9 | 8.3 | 8.4 | 7.3 |
| Females | | | | | |
| All sites | CIR | 72.8 | 80.7 | 84.5 | 83.7 |
| | AAIR | 101.8 | 115.5 | 124.6 | 127.2 |
| | CDR | 37.2 | 39.2 | 41.8 | 36.9 |
| | AADR | 55.5 | 59.3 | 65.1 | 60.6 |
| Breast | CIR | 16.1 | 18.7 | 21.1 | 22.4 |
| | AAIR | 22.2 | 26.2 | 30.0 | 33.1 |
| | CDR | 6.8 | 7.9 | 8.4 | 7.3 |
| | AADR | 10.0 | 11.7 | 12.6 | 11.5 |
| Cervix | CIR | 12.3 | 12.1 | 12.4 | 11.7 |
| | AAIR | 16.9 | 16.7 | 18.2 | 17.2 |
| | CDR | 3.5 | 3.9 | 4.2 | 3.3 |
| | AADR | 5.3 | 5.7 | 6.3 | 5.4 |

The death rate from mouth cancer was quite low compared to other important sites of cancer. However an increase was noted during 1989 to 2001 in CDR as well as AADR both (Table 3). Looking at the age specific rates, there were very few exceptions to the rates being less than 10 deaths per 100000 person years through out the 5-year age groups. There was no death from mouth cancer under the age of 25 years across the four calendar years under study.

Lung cancers in males: A decline in the crude rate of lung cancer was observed during 1997-2001 (Table 3). Lung cancer, with tobacco as the main cause and a longer

latent period, occurs at the older ages compared to other cancers. An age specific rate of less than 10 per 100,000 person years was observed for the age groups before the age of 50 years. Thus most of the lung cancers occurred after the age of 50 years. During 1989-2001, age specific rates declined in all the age groups with the highest decrease in persons aged 70 years or more.

The pattern of deaths due to lung cancer was similar to that of incidence (Table 3). Looking at the age specific rates, the risk of death declined in all the age groups during 1989-2001. The quantum of decline was highest among the persons age 70 years and more.

Female breast cancers: In Mumbai, the incidence of female breast cancer increased from a crude rate of 16.1 in 1989 to 22.4 per 100,000 person years in 2001. Correspondingly, AAIR also increased (Table 3). The occurrence of breast cancer starts from the age of around 30 years with the incidence under the 30 years of age being really low. Looking at the age specific incidence rates of breast cancer, it was noted that during 1989 to 2001, the rate increased in all the age groups with the exception of 55-69. A higher increase was noticed in the elder age groups.

CDR of female breast cancer increased and then declined. Correspondingly AADR also increased and then declined. The risk of death due to breast cancer started around the age of 40 years and increased with age. The decline in AADR during 1997-2001 was evidenced with a decline in the age specific rates for all the age groups.

Uterine cervical cancers: There was an indication of decline in the risk of cervical cancer from 1989 to 2001. (Table 3). There was no incidence of cervical cancer before the age 20 years and less than 10 cancers per 100,000 person years in the age group 20 to 34 years. During 1997 to 2001, a decrease was noticed in the risk of cervical cancer in all the age groups and the same was depicted in AAIR.

Pattern in the death rates of cervical cancer was similar to that in incidence, a decline from 1993 to 2001 (Table 3). Looking at age specific rates, cervical cancer deaths were not seen before the age of 30 years and were rare before the age of 50 years (less than 10 deaths per 100,000 person years). Thus most of the deaths from cancers of uterine cervix occurred among the women aged 50 years and above. A comparison of age specific rates in 1989 and 2001 showed that there was decline in the risk of cervical cancer death among the women aged less than 65 years. The risk had increased among the women aged 65 years or older.

2.4 Survival indices (Table 4)

The length of real life at birth increased from 61.5 years in 1989 to 62.7 years in 2001 in males and from 66 to 67.1 years in females.

All sites: The PYFD increased in both sexes but concerning PYWD, a decrease was observed in males whereas an increase was noted in females. Correspondingly, ADD declined in males and increased in females. Expectation of life in the absence of the disease, i.e., imaginary life was 62.4 and 67.1 years in males and females respectively in 1989 resulting in PYLL of 0.91 years in males and 1.13 years in females. By the year 2001, PYLL decreased to 0.75 years in males and to 0.90 years in females. Thus there is an indication of improvement in the overall level of prognostic factors especially in case of females.

Mouth cancers in males: Person years free of disease increased from 59.9 to 62.6 years. PYWD for mouth cancer in males was 0.05 to 0.07 year. ADD was higher compared to other sites of cancer under study and also compared to all sites of cancer. It declined from 7.45 years in 1989 to 5.65 years in 1997 and then increased to 6.48 years in 2001. The length of imaginary life increased in correspondence with the real life resulting in a constant PYLL of 0.02 year.

Lung cancers in males: Lung cancer is a highly fatal disease resulting in a shorter survival duration compared to other sites of cancer under study. PYWD varied between 0.03 and 0.04 year during the study period. There was no consistent trend in ADD, it was 2.05, 2.38, 1.93 and 2.32 years in the four calendar years under study. A higher

**Table 4. Length of Real Life, Person Years Free of Disease (PYFD) and With Disease (PYWD), Length of Imaginary Life (IL), Person Years of Life Lost (PYLL) and Average Duration of Disease (ADD) for the Four Calendar Years under Study**

| Site of cancer | | 1989 | 1993 | 1997 | 2001 |
|---|---|---|---|---|---|
| Males | Real life | 61.47 | 61.75 | 62.16 | 62.65 |
| All sites | PYFD | 60.76 | 61.11 | 61.57 | 62.08 |
| | PYWD | 0.71 | 0.64 | 0.59 | 0.57 |
| | IL | 62.38 | 62.63 | 62.96 | 63.41 |
| | PYLL | 0.91 | 0.88 | 0.80 | 0.75 |
| | ADD | 5.17 | 4.89 | 4.53 | 4.41 |
| Mouth cancer | | | | | |
| | PYFD | 61.42 | 61.69 | 62.12 | 62.58 |
| | PYWD | 0.06 | 0.06 | 0.04 | 0.07 |
| | IL61.49 | 61.77 | 62.19 | 62.68 | |
| | PYLL | 0.02 | 0.02 | 0.02 | 0.02 |
| | ADD | 7.40 | 7.33 | 5.60 | 6.46 |
| Lung Cancers | | | | | |
| | PYFD | 61.43 | 61.71 | 62.13 | 62.62 |
| | PYWD | 0.04 | 0.03 | 0.03 | 0.03 |
| | IL61.60 | 61.85 | 62.26 | 62.73 | |
| | PYLL | 0.12 | 0.10 | 0.10 | 0.07 |
| | ADD | 2.05 | 2.38 | 1.93 | 2.31 |
| Females | Real life | 65.96 | 66.24 | 66.63 | 67.06 |
| All sites | | | | | |
| | PYFD | 65.06 | 65.23 | 65.64 | 65.99 |
| | PYWD | 0.90 | 1.01 | 0.99 | 1.07 |
| | IL | 67.09 | 67.33 | 67.71 | 67.96 |
| | PYLL | 1.13 | 1.08 | 1.08 | 0.90 |
| | ADD | 4.12 | 4.43 | 4.22 | 4.63 |
| Breast cancers | | | | | |
| | PYFD | 65.72 | 65.97 | 66.32 | 66.70 |
| | PYWD | 0.24 | 0.27 | 0.30 | 0.35 |
| | IL | 66.16 | 66.45 | 66.83 | 67.23 |
| | PYLL | 0.20 | 0.21 | 0.21 | 0.17 |
| | ADD | 4.63 | 4.69 | 4.93 | 5.22 |
| Cervical cancers | | | | | |
| | PYFD | 65.73 | 66.04 | 66.43 | 66.86 |
| | PYWD | 0.23 | 0.21 | 0.20 | 0.20 |
| | IL | 66.06 | 66.35 | 66.73 | 67.14 |
| | PYLL | 0.10 | 0.10 | 0.11 | 0.08 |
| | ADD | 5.33 | 5.35 | 4.88 | 5.43 |

increase was noted in the length of imaginary life than real life resulting in a declining PYLL. During 1989-2001, PYLL declined from 0.12 to 0.07 year.

Female breast cancers: The PYWD as well as ADD were observed to have increased during 1989-2001. The length of imaginary life increased almost in the correspondence with real life. Thus in case of female breast cancer, there was evidence of improvement in survival.

Uterine cervical cancers: An increase in PYFD was observed. PYWD at birth declined during the same period. ADD however, although not consistently, increased. Expectation of life lost to disease varied between 0.08 and 0.11 year. There was an indication of improvement in the prognostic factors of cervical cancer.

2.5 ADD by age

As far as `all sites' are concerned, age pattern in ADD was similar in both sexes, there was slight increase at the age of 15 years and consistent decline thereafter, especially in females. In case of individual sites, there was slight increase in ADD during the early ages of cancer occurrence and thereafter a consistent decline was noted.

3. Validation (Table 5)

It was observed that our estimates were comparable in case of female breast and uterine cervical cancers. In case of mouth and lung cancers in males, our estimates were higher than the median duration based on published survival rates.

4. Advantages and limitations of the proposed method

Advantages: The proposed method has the multi-dimensional advantages over the direct method in terms of time, cost, and analytic calculations.

a) As the proposed method is based on secondary data, it does not necessitate the collection of primary data.

b) Cost by proposed method is negligible compared to that by follow-up method.

c) Proposed method facilitates the study of survival at a regular interval (as regular as on an annual basis).

d) The computational procedure of the proposed method is relatively easy to perform.

e) Proposed method facilitates the study of survival for more than one disease or site of cancer together.

f) Proposed method although gives a hypothetical index, it is based on the experience of the current data. In contrast, the follow-up method although gives a real measure, it gives the experience of the patients diagnosed 10-15 years before.

g) Proposed method reflects the effect of preventive measures also in terms of change in PYFD.

h) Proposed method facilitates comparison over time period.

Limitations: Disadvantages of the proposed method are limited by the stability of morbidity and mortality in the population under study and also the completeness of morbidity and mortality data.

a) The main disadvantage is that the indices defined and computed are valid in a scenario of stable morbidity and mortality.

**Table 5. Comparison of ADDs Estimated in this Study with Median Duration Estimated Based on 1, 3 and 5-year Survival Rates Reported from Classical Survival Studies**

| Site of cancer | Cases | Survival* | | | Duration# |
|---|---|---|---|---|---|
| | | 1-yr | 3-yr | 5-yr | |
| Female breast cancer | | | | | |
| Yeole et al, 2004 | 2,516 | 76.0 | 51.5 | 41.8 | 3.3 |
| Yeole et al, 1998 | 2,872 | 84.2 | 61.9 | 51.1 | 5.2 |
| Nandakumar et al, 1998 | 1,361 | 82.2 | 55.5 | 41.7 | 3.8 |
| Shanta et al, 1998 | 1,346 | 82.3 | 57.2 | 45.9 | 4.3 |
| Gajalakshmi et al, 1997 | 1,747 | 79.9 | 58.4 | 47.5 | 4.5 |
| Present study, 2008 | | | | | 4.6-5.2 |
| Uterine cervical cancer | | | | | |
| Yeole et al, 2004 | 1 620 | 77.0 | 55.9 | 44.0 | 4.0 |
| Yeole et al, 1998 | 2 354 | 81.0 | 56.0 | 47.7 | 4.4 |
| Nandakumar et al, 1998 | 2,155 | 76.4 | 50.5 | 37.6 | 3.1 |
| Shanta et al, 1998 | 3,289 | 87.9 | 67.4 | 56.3 | 6.1 |
| Jayant et al, 1998 | 247 | 62.8 | 36.2 | 30.9 | 2.0 |
| Jayant et al, 1996 | 79 | 53.2 | 26.6 | 25.3 | 1.2 |
| Jayant et al, 1996 | 111 | 64.0 | 44.0 | - | 2.4 |
| Present study, 2008 | | | | | 4.9-5.4 |
| Mouth cancer | | | | | |
| Yeole et al, 2003 | 977 | 58.5 | 40.1 | 33.4 | 1.9 |
| Yeole et al, 2000 | 1,505 | 71.7 | 48.1 | 40.6 | 2.8 |
| Shanta et al, 1998 | 931 | 76.0 | 43.7 | 28.8 | 2.6 |
| Present study, 2008 | | | | | 5.6-7.4 |
| Lung cancer | | | | | |
| Yeole, 2005 | 1,230 | 29.9 | 15.9 | 12.5 | <1.0 |
| Yeole & Kumar, 2004 | 1,995 | 19.9 | 8.0 | 5.7 | <1.0 |
| Shanta et al, 1998 | 656 | 40.3 | 10.6 | 6.6 | <1.0 |
| Present study, 2008 | | | | | 1.9-2.4 |

*Observed survival (%), #Median duration (Years)

b) The proposed method provides only hypothetical indexes not the real measures.

c) This method does not help in evaluating the role of different prognostic factors.

d) It does not help in the evaluation of different therapeutic efficacies.

e) The proposed method requires the data on general mortality in the population. In strict terms however, it may not be counted as the disadvantage of the proposed method because even in follow-up method one requires data on mortality.

## Discussion

Knowledge of survival of a disease is essential in the community level management of a disease. The knowledge of survival of a disease over a period of time helps in monitoring and controlling the levels of prognostic factors in the population. There is no survival study in India associating the level of prognostic factors with the survival over a period of time. For example, there are studies reporting education and stage of the disease as the independent predictors of survival. But there is no study correlating the trends in the levels of education and stage of disease with the survival rates. In view of the difficulties in the conduct of prospective survival studies, the present study was planned to propose a method for an indirect study of survival. The proposed method is going to be useful in having a regular audit of the prognostic factors

in the society.

Although several population-based registries are operating in the country, reliable mortality data is available only for Mumbai registry for a long duration, and a few other registries, which are of recent origin. In India, cause wise mortality rates at the country/state level are not available as the National Health Information is still in the process of development. The present exercise was limited to mortality data obtained from Mumbai PBCR only. The death survey system in Mumbai seems to be fairly reliable and accurate. No dead body can be disposed off without a death certificate from a competent authority and all deaths have to be certified by the Registered Medical Practitioner as per law. Measures such as cancer incidence, mortality, mortality-incidence ratio and survival data provide a means to assess the effectiveness of overall cancer services.

Two main considerations in estimating population for a registry area are; one, to ensure that the definitions of a PBCR case is taken into consideration while estimating population, and two, to ensure the use of a growth rate as close to the truth as possible specially in case of projections out side the inter censal period. First consideration was ensured by taking base population, i.e., for the years 1991 and 2001 reported by MCR which must be quite accurate because these were based on forward projection for a gap of just 4 months from the reference date of respective Census. Second consideration was ensured by the fact that it was an inter-census estimation for the years 1993 and 1997 and backward projection at a gap of just 2 years in case of 1989.

The results of our analysis represent an average level of prognostic factors of cancer in Mumbai. There have not been many reports on survival from cancer in India, mainly because of poor patient follow-up and inadequate system of registration of death. In the absence of carrying out well conducted survival analysis and considering the ways to have an audit of prognostic factors at minimal cost, the present method may be one of the procedures. The present study findings have indicated that duration of disease for all sites was 4.4 and 4.6 years for males and females respectively. Higher survival duration observed amongst females may be due to better prognosis for certain conditions amongst females. In males, conditions such as cancer of the lung and esophageal cancers have a worst prognosis. Further, analysis according to various sites indicated that the magnitude of cancer problem is more pronounced in females as compared to males mainly due to the high risk of development of breast and cervical cancers and other cancers of female genital organs that occur in the reproductive age groups.

An indication of improvement in survival indices for all sites of cancer taken together as well as for individual sites under study was observed in females. One of the possible explanations for this may be the improvement in the level of prognostic factors in Mumbai. Education and stage of disease have been consistently reported as the independent predictors of survival. As far as education is concerned, in terms of overall literacy rate, it increased from 71.5 to 87% during 1991 to 2001. Regarding stage of disease, no data is available in India to ascertain trend in the stage of disease at reporting in a population. In the absence of some thing concrete however, hospital cancer registries, although prone to various biases, give some idea of the situation. According to the reports of NCRP based on the data for the years 1984-1993 (NCRP, 2001) and 2001-2002 (NCRP, 2005), there was an improvement in the stage of disease at the time of reporting at Tata Memorial Hospital (TMH), Mumbai. During the above period, the proportion of localised cancers increased from 32 to 53 percent for breast cancer and 12 to 25 percent for cervical cancer. In case of all sites also proportion of localised cancers increased from 23 to 38 percent in females.

In contrast to the situation in women, a decreasing trend was observed in ADD for men for all sites as well as for mouth cancer. This may be due to the improvement in the cancer death registration system during the study period. It may be noted that during the study period, age adjusted cancer death rate increased from 59 to 67 deaths per 100000 person years for all sites and from 1.2 to 2 deaths per 100000 person years for mouth cancer.

The duration of disease estimated through another approach based on median age at incidence and mortality has been reported to be 2.5 and 3.6 years respectively for males and females for all sites of cancer, 2.1 years for mouth cancers and 0.8 year for lung cancer in males and 3.3 and 2.8 years respectively for breast and cervical cancers in females (Dhar et al, 2006a). It was reported that these estimates were under estimates due to various biases that could not be controlled. Thus a higher ADD reported by present study is consistent. Dhar et al (2006a) also reported that the under estimation was of the degree of 30 to 40 percent. Thus after escalation of their findings by 30 to 40 percent, the results appear comparable with the results of present study.

This study has reported decreasing ADD with increase in age at diagnosis after the age of 40 to 45 years. This finding is consistent with the finding of Gajalakshmi et al (1997) reporting for female breast cancer that increasing age at diagnosis is associated with decreased survival.

For a developed country like Finland, the ADD based on reported incidence and prevalence (Finnish Cancer Registry, 2005) works out to 5.5 and 8.6 years respectively for males and females for all sites of cancer, 6.5 years for mouth cancers and 1.5 year for lung cancer in males and 11.0 and 19.6 years respectively for breast and cervical cancers in females. Our estimates revealed a lower value of the estimates compared to Finland, except in the case of lung cancer. Following are some of the reasons for a lower ADD in our country; late stage at reporting, non-acceptance of the treatment, incomplete or partial treatment, etc. Dhar et al (2006b) reported that in case of cervical cancer, up to half of the patients registered at Tata Memorial Hospital, Mumbai, Kidwai Memorial Institute of Oncology, Bangalore and Cancer Institute, Chennai did not receive a complete course of cancer directed treatment and the majority (65 to 92 percent) reported the disease either with regional spread or lymph node involvement or both.

Direct validation of the results was not possible, because that requires follow-up procedure for a very long

period. This is the reason we do not see cohort life tables for mortality. Conceptually, the methods described appear as valid as the validity of a life table itself with some additional assumptions. Let us have a brief view of the validity of the life table estimates. The construction of life tables is based on some assumptions. The foremost is about the stability of the age distribution of deaths and population. Another assumption is involved in the calculation of probabilities of death using death rates. This is about the distribution of deaths within a particular age group or in other words, about the length of a particular age group lived before dying by those died in that age group. While estimating person years lived (i.e., lx column), we introduce another assumption and this is that the life table deaths within a particular age group are evenly distributed. All these assumptions are well established and accepted by Demographers and Actuaries.

Now coming to the proposed methodology, it is based on the construction of different life tables. All the assumptions inherent with the life tables get directly included. In addition since the direct method makes use of the current data on incidence and mortality due to cancer, the assumtion of stability is expanded to include the incidence and mortality due to cancer. One assumption is involved in the calculation of radix column of second life table whereas another one is involved in the calculation of probability of death in the assumed absence of the considered cause of death used in the construction of third life table. Former one is that the cohort is exposed to the risk of the disease first and then to the risk of death due to other causes. Latter one is that the persons died from a particular cause would have been exposed to the same intensity of competing causes had the considered cause not in existence as in the case of existence of the considered cause.

Given the difficulties in conduct of classical survival studies, the proposed method may provide a useful tool for regular audit of prognostic factors in the community in the set up of developing countries where limited resources are available for a prospective survival study.

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