Denominators: An attempt to adjust for cancer incidence and mortality rates and its role in cancer registries

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Abstract
Cancer is an important public health burden in India and around the Globe. Incident cases of cancer are reported continuously, and trends in incidence rates vary among five yearly age group. In India National census is carried out after every 10 years since 1951, the latest census is carried out in 2011. As incident cases of cancer are reported continuously for 5 year age group and estimation of rates and trends for a given year of interest fall in-between two census period population estimation of five yearly age group, which serves as Denominator sense importance. Denominator serves as the most essential part of any cancer registry program as it used for calculation of various rates for five yearly age group such as age-standardized rate, crude rate, truncated rate, cumulative risk etc., Calculated by different registries and Individual Researchers, Government organizations, etc. Currently most of the registries used individual exponential growth rate and differential distribution method to estimate the growth rate. However, it is found that the calculated rates and risk be suffering from bias most of the time since some method over and underestimate the growth rate while some does not able to maintain consistency. Here, an attempt is made to adjust the world standard population with two census period to estimate the five yearly age group for a given year of interest of a geographical region falls in-between two census period. It is also shown here that how the proposed model “age-adjusted population growth model” maintain the overall growth as in exponential growth model and difference distribution method also maintains the estimated growth rate as is found in difference distribution method. Further, it is tried to highlight the points how these method overcomes the problems compared with other methods that are currently used by registries.

Key words: Census, denominators, cancer incidence, cancer mortality, growth rate, world standard population

Introduction
The cancer registry is an essential part of any national programme of cancer control. Population Based Cancer Registry (PBCR), kamrup urban (Guwahati, Assam, North East India), which is a part of National Cancer Registry Programme (NCRP), Indian Council of Medical Research, is formed in 2003 and one of the oldest Cancer registry in India and North East (N.E.) India. In N.E. India Cancer research works are done by various Institutions, Individual Researchers and Government Organizations; it is quite significantly noticed that N.E. India has a different kind of gene bank for different five yearly age group population compared to other parts of India and World population. Primarily incidence and mortality data’s are collected from various sources like Hospitals, Public health units, Pathology laboratories, X-ray centers, Pain and Palliative Care Clinic, Nursing Homes, Birth and Death Registration Centers and then analyzed and expressed these incident cases in terms of different rates and ratios like Crude Rate (CR), age specific rate (age-adjusted rate) and truncated rate (TR). All the mentioned rates necessarily depends upon the age distribution of the population of the geographical area of interest.

Cancer is an important public health burden in India and around the Globe. Incident cases of cancer are reported continuously, and trends in incidence rates vary among five yearly age group. It is well-accepted that risk of developing cancer are well-affected by the lifestyle choices and there is strong evidence that an individual’s risk of developing cancer is quite different so it is necessary for us to know the estimated five yearly age group of that region for the year of interest to compare the incidence and mortality rates and its impact with other region of the country with other parts of the world, So we can take some preventive steps like awareness program, etc., to control the burden of Cancer.

In India National census is carried out after every 10 years since 1951, the latest census is carried out in 2011. Where a new concept of caste based census is included. Hence for Cancer registries to estimate the rates and ratios as mentioned for a year of interest of a geographical region have to be a project the population growth through some population growth methods or models. Projection of population through different models and different methods is nothing but an attempt to scientifically predict the future using the data currently available at present. The projections depend on the accuracy of input data and the assumptions made in respect of the future trends of various components.

Most developed and western countries have a higher proportion of the older population while developing countries like India have a higher proportion of the young population. Hence in order to make incidence rates of cancer comparable between developed and developing countries an adjusted population growth model is necessary. A world standard population that takes this into account is used to arrive for this adjusted model.

The methods which are currently used by most of the Cancer registries for five yearly age group data are the individual exponential growth method and difference distribution method. However, the proposed model is nothing but an attempt to make a simplified model adjusted through world standard population. The proposed model “age-adjusted population growth model” is adjusted for five yearly age group data using standard world population as described by NCRP.

The present paper is an attempt to make projection of five yearly age group population by standardizing it with standard world population and to overcome the problem of estimated five yearly age group population used as denominators in calculating different rates and ratios mentioned as above in cancer research.

Materials and Methods
In cancer research, interpreting and analysis of various rates and ratios we mostly have to deal with the five yearly age group populations: 0-4; 5-9; 10-14; 15-19; 20-24; 25-29; 30-34; 35-39; 40-44; 45-49; 50-54; 55-59; 60-64; 65-69; 70-74; 75 and above; where \( j = 1,2,3,\ldots,16 \) is used to refer the groups; for example \( j = 5 \) then 20-24 age group is referred and if \( j = 16 \) the 75 and above age group is referred.
**Exponential growth model**

If we assume that population growth remain as it for a time period \( t \) and considering that population of the region \( x_0 \) will be grown up to \( x_t \) after \( n \) number of years (assuming \( x_0 \) be the 1st census and \( x_n \) be the last census) then annual growth rate \( 'r' \) is expressed in terms of the formula as:

\[
r = (x_t/x_0)^{1/n} - 1
\]

\( x_t = x_0 (1 + r)^t \) where \( 0 < t < n \)

\( x_t = x_0 (1 + r)^t \) where \( t > n \)

**Individual exponential growth model**

This method makes use of the five yearly age distribution of immediately preceding two census years.[4] Considering for a geographical region of interest \( g_{j01} \) and \( g_{j91} \); \( j = 1, 2, 3...16 \) defined for five yearly age group for the census year 1991 and 2001 respectively. Here we calculate the population projection growth rate \( r_{j0191} \) for \( n = 10 \). Then for \( j^{th} \) five yearly age distribution for the geographical region of given time period \( 't' \) population projection estimates \( g_p \) is given as described below:

Let \( r_{j0191} = (g_{j01}/g_{j91})^{1/n} - 1 \)

**The difference distribution method**

Considering for the given region of census 1991 and 2001 respectively for the five yearly age group population; \( j = 1, 2, 3...16 \) then difference \( (d_{j0191}) \) is calculated in the population and proportion is expressed as \( (x_{j0191}) \), where overall difference is expressed as \( D_{0191} \). Thus expressed in the equation as:

\[
d_{j0191} = g_{j01} - g_{j91} \quad \text{for } j = 1, 2, 3...16
\]

\[ D_{0191} = \sum d_{j0191} \quad \text{for } j = 1, 2, 3...16 \]

\[ X_{j0191} = (d_{j0191}/D_{0191}) \quad \text{for } j = 1, 2, 3...16 \]

To estimate the five yearly age groups populations for the time period \( t \), the Difference Distribution method need Base population \((x_{1991})\) and population at time \( t \) \((x_t)\) and then followed as follows:

Condition 1: \( D_{j01} = (x_t - x_n) \) then

\[ g_p = g_{j01} + (D_{j01} \times x_{j0191}) \quad \text{for } j = 1, 2, 3...16 \]

where \( 1991 < t < 2001 \);

Condition 2: \( D_{j01} = (x_t - x_n) \) then

\[ g_p = g_{j01} + (D_{j01} \times x_{j0191}) \quad \text{for } j = 1, 2, 3...16 \]

where \( t > 2001 \);

**Age adjusted population growth model**

Assuming population growth remain constant for \( 't' \) and considering that population of the region \( X_j \) will be grown up to \( X_t \) after \( n \) number of years so that annual growth rate \( 'r' \) is expressed in terms of the formula as--

\[
r = (X_t/X_0)^{1/n} - 1
\]

\( X_t = X_0 (1 + r)^t \) \( 0 < t < n \)

\( X_t = X_0 (1 + r)^t \) \( t > n \)

Considering for the \( g_{j01} \) and \( g_{j91} \) are the geographical region of census 1991 and 2001 respectively and \( W_j \) is the world standard population for the five yearly age group; \( j = 1, 2, 3...16 \) then difference \( (d_{j0191}) \) is calculated in the population and proportion is expressed as \( (X_{j0191}) \), where over all difference is expressed as \( D_{0191} \), then adjusted population growth is expressed in the equation as:

\[
d_{j0191} = g_{j01} - g_{j91} + W_j \quad \text{for } j = 1, 2, 3...16
\]

\[ D_{0191} = \sum d_{j0191} \quad \text{for } j = 1, 2, 3...16 \]

\[ X_{j0191} = (d_{j0191}/D_{0191}) \quad \text{for } j = 1, 2, 3...16 \]

Assuming that population growth remain as it is after 2001 and considering Chennai PBCR data used as Census 1991 and 2001 for five yearly age group distribution demonstrated the projection for 2003 using Age-Adjusted Population Growth Model.

**Results and Observation**

Table 1 provides the projected population of Chennai PBCR region for the year 2003 of five yearly age group considering 1991 census as a base year and considering population growth remains constant after 2001. Where \( g_{91} \) and \( g_{01} \) be the five yearly age group population censuses of 1991 and 2001, tabulated in column nos. 2 and 3; whereas in column nos. 4, 5 and 6, Population growth rate, estimated growth rate and Adjusted Estimated growth rate are shown.

The overall growth rate is found 0.112 with a variation of -0.0089 to 0.0547 for the exponential model. The estimated five yearly age group population for the year 2003 using the individual exponential growth rate is 2332051 while using the overall exponential growth rate; it comes out to be 2269379, with a correction factor 0.9731 (=226397/2332051) which is adjusted to meet overall exponential growth rate as shown in column 6.

Table 2 shows the five yearly age groups population projection using Differential Distribution method. In column 2 and 3; five yearly age group populations of census year 1991 and 2001 is illustrated. The Difference and Difference proportion is shown in Column 4 and 5. Whereas in column no. 6 estimated growth rate of 2003 and Estimated population is shown in column no. 7. It is shown that in 0-4 years and 5-9 years the population estimates shown decreasing trend whereas other age groups shown increasing trends compared with 2001.

Table 3 shows the five yearly age groups population projection using age-adjusted population growth model; showing 1991 and 2001 census population in column 2 and 3 and in column no. 4, Annual growth rate is shown, whereas 0-4 and 5-9 years age group population shown negative growth rate, but interestingly the estimated population growth rate is positive in 0-4 age group population and all other five yearly age group shows positive growth rate.

**Discussion**

From Table 1 have noticed that Estimated population for 2003 using individual exponential growth rate is 2332051 whereas Estimated population adjusted using overall exponential growth rate is 2269379, which clearly points the problem of overestimation. Furthermore, when a correction factor is adjusted to individual exponential growth rate model, observed significant depreciation in individual growth rate for different five yearly age group population. It has been also noticed negative growth rate for the five yearly age group 0-4 and 5-9, which is not quite justifiable, since after 5 years the total population of one group moves to another group that means the entire population of 0-4 age group moves to 5-9 age group, this are the some points which
shows the model is not a quite suitable one for representation of cancer rates and ratios, since estimated population plays the most important rule to find out the various rates and ratios. Whereas from Table 2, the difference distribution method is more suitable one than exponential one since it has maintain both negative as well as positive growth rate, but it also shows fails to maintain the concept of migration of one group population to other group likewise 0-4 age group to 5-9. Whereas, the proposed model From Table 3, “Age-Adjusted Population Growth Model” maintains the overall growth rate, that is, 2269379 as in Exponential growth model and Difference distribution method and maintains the estimated growth rate is as found in Difference distribution method, that is, the estimates growth by 2003 which is found as 49481 is same as Difference distribution method. It is quite significantly found that maintaining the estimated growth rate is as difference distribution method the proposed model “age-adjusted population growth model” shows the Estimated growth for five yearly age group 0-4 is positive, however for the five yearly age group 5-9 shows negative growth, but it is lowered down to a minimum level and maintains the positive growth rate for all other age group which shows the proposed model how overcome the limitations of Individual exponential growth model and difference distribution method.

Population based cancer registries are solely dependent on the estimated population of five yearly age group data, which is used to calculate different rates and ratios like CR, Age specific rate, TR and different mortality rates. These five yearly age group populations is also used to estimate the future trends.
Kalita and Nirmolia: Denominators role in cancer registry

Table 3: Estimation of five yearly age group through age adjusted population growth model

| Age group | 1991 census | 2001 census | Growth rate 1991-2001 | World standard population (W) | Adjusted population growth (d) | Adjusted population growth proportion (p) | Estimated growth by 2003 | Estimated population growth by age group |
|-----------|-------------|-------------|-----------------------|--------------------------------|---------------------------------|------------------------------------------|-------------------------|---------------------------------------|
| 0-4       | 167407      | 156443      | -0.0068               | 12000                          | 1036                            | 0.0031                                  | 155                     | 156598                                |
| 5-9       | 191025      | 174686      | -0.0089               | 10000                          | -6339                           | -0.019                                  | -948                    | 173738                                |
| 10-14     | 195524      | 200575      | 0.0026                | 9000                           | 14051                           | 0.0422                                  | 2101                   | 202676                                |
| 15-19     | 198581      | 216803      | 0.0088                | 9000                           | 27222                           | 0.0817                                  | 4071                   | 220874                                |
| 20-24     | 216844      | 231618      | 0.0066                | 8000                           | 22774                           | 0.0683                                  | 3406                   | 235024                                |
| 25-29     | 200616      | 226999      | 0.0124                | 8000                           | 34383                           | 0.1032                                  | 5142                   | 232141                                |
| 30-34     | 168146      | 197627      | 0.0163                | 6000                           | 35481                           | 0.1065                                  | 5306                   | 209293                                |
| 35-39     | 151786      | 181515      | 0.018                | 6000                           | 35729                           | 0.1072                                  | 5344                   | 186589                                |
| 40-44     | 125427      | 148448      | 0.017                 | 6000                           | 29021                           | 0.0871                                  | 4340                   | 152788                                |
| 45-49     | 98541       | 130115      | 0.0282                | 6000                           | 37574                           | 0.1127                                  | 5619                   | 135734                                |
| 50-54     | 81152       | 104987      | 0.0261                | 5000                           | 28835                           | 0.0865                                  | 4312                   | 109299                                |
| 55-59     | 62384       | 70861       | 0.0128                | 5000                           | 12477                           | 0.0374                                  | 1866                   | 72727                                 |
| 60-64     | 52094       | 64215       | 0.0211                | 4000                           | 16121                           | 0.0484                                  | 2411                   | 66626                                 |
| 65-69     | 31846       | 44587       | 0.0342                | 3000                           | 15741                           | 0.0472                                  | 2354                   | 46941                                 |
| 70-74     | 22924       | 32622       | 0.0359                | 2000                           | 11698                           | 0.0351                                  | 1750                   | 34372                                 |
| 75+       | 21982       | 37437       | 0.0547                | 2000                           | 17455                           | 0.0524                                  | 2611                   | 40408                                 |
| Total     | 1986279     | 2219538     | 0.0112               | 100000                         | 333259                          | 1                                      | 49841                  | 2269379                               |

D_{0191} = \sum(d_{0191}) = 33259
P_{01} = p_{01} * (1 + r_{0191})^2 = 2269379
P_{03} = 2219538
D_{03} = P_{03} * p_{03} = 49841

of incident and mortality rates of various cancer sites like leukemia; one of the common cancer site in child age group, so if the estimated population is always shows a negative growth then the calculated rates automatically goes down which is in fact not a quite justifiable one, other site such as esophagus, breast, lung etc., are also solely dependent on the estimated population. Hence, the proposed model “age-adjusted population growth model” is not only useful to estimate the time trend, but also to find out the various rates and ratios.

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References

1. Parkin DM, Whelan Sl, Ferlay J, Teppo M, Thomas DB. Cancer Incidence in Five Continents. Vol. VIII. Lyon, France: IARC Press; 2002.
2. Esteve J, Benhamou E, Raymond L, editors. Statistical Methods in Cancer Research: Descriptive Epidemiology. Vol. IV, France: IARC Scientific Publications No. 128; 1994. p. 313.
3. National Cancer Registry Programme (ICMR). Consolidate Report of the Population Based Cancer Registries: 1990-1996. Bangalore, India; 2001.
4. Takiar R, Shobana B. Cancer incidence rates and the problem of denominators - a new approach in Indian cancer registries. Asian Pac J Cancer Prev 2009;10:123-6.

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