Article published online: 2020-12-31

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

Manoj Kalita, Tulika Nirmolia[1]

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 is as 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)[1] 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 or with other parts of the world, So we can take some preventive steps like awareness program, etc., to control the burden of Cancer.

Access this article online
Quick Response Code:
Website: www.sajc.org
DOI: 10.4103/2278-330X.149943

Dr. B. Borooah Cancer Institute, Department of Population Based Cancer Registry, National Cancer Registry Programme, Indian Council of Medical Research, Guwahati, [1]Department of Biotechnology, Assam Medical College and Hospital, Dibrugarh, Assam, India

Correspondence to: Mr. Manoj Kalita, E-mail: manojkalita5354@gmail.com

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[2] as described by NCRP.[3]

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 dealt 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...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 grouped is referred.

Exponential growth model

If we assume that population growth remain as it is for a time period 't' and considering that population of the region x_0 will be grown up to x_n 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:

$r = (x_n/x_0)^{1/n} - 1$

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

$x_t = x_n (1 + r)^t$ 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_{j91} and g_{j01}; $j = 1, 2, 3... 16$ defined for five yearly age group for the census year 1991 and 2001 respectively. Here we calculate the population projection growth rate r_{i0191} for $n = 10$. Then for j^{th} five yearly age distribution for the geographical region of given time period 't' population projection estimates g_{jt} is given as described below:

Let $r_{j0191} = ({}^{g}{}_{j01/}{}^{g}{}_{j91})^{1/10} - 1$

Condition 1: $g_{jt} = g_{j91}(1 + r_{j0191})^t$ for $j = 1, 2, 3...16$.
where $1991 < t < 2001$;

Condition 2: $g_{jt} = g_{j01}(1 + r_{j0191})^t$ for $j = 1, 2, 3...16$.
where $t > 2001$;

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:

$d_{j0191} = g_{j01} - g_{j91}$ for $j = 1, 2, 3...16$

$D_{0191} = \sum d_{j0191}$ for $j = 1, 2, 3...16$

$X_{j0191} = (d_{j0191}/D_{0191})$ 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: $D_{t91} = (x_t - x_{91})$ then

$g_{jt} = g_{j91} + (D_{t91} * x_{j0191})$ for $j = 1, 2, 3...16$
where $1991 < t < 2001$;

Condition 2: $D_{t01} = (x_t - x_{01})$ then

$g_{jx} = g_{j01} + (D_{t01} * x_{j0191})$ 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_0 will be grown up to X_n after n number of years so that annual growth rate 'r' is expressed in terms of the formula as–

$r = (X_n/X_0)^{1/n}-1$

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

$X_t = X_n (1 + r)^t$ $t > n$

Considering for the g_{j91} and g_{j01} are the geographical region of census 1991 and 2001 respectively and Wj 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:

$d_{j0191} = g_{j01} - g_{j91} + w_j$ for $j = 1, 2, 3...16$

$D_{0191} = \sum d_{j0191}$ for $j = 1, 2, 3.16$

$X_{j0191} = (d_{j0191}/D_{0191})$ 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

Table 1: Estimation of five yearly age group through individual growth method

Age group	1991 census (a_{i91})	2001 census (a_{i01})	Growth rate 1991-2001 ($r_{i0191}=a_{i01}/a_{i91})^{1/10}-1$	Estimated population 2003 $a_{i03}=a_{i01}*(1+r_{0191})^2$	Estimated population adjusted to 2003 $a_{i03}*(p_{03}/\sum a_{i03})$
1	2	3	4	5	6
0-4	167407	156443	−0.0068	154338	150190
5-9	191025	174686	−0.0089	168549	164019
10-14	195524	200575	0.0026	202632	197186
15-19	198581	216803	0.0088	224552	218517
20-24	216844	231618	0.0066	237806	231415
25-29	200616	226999	0.0124	238499	232090
30-34	168146	197627	0.0163	210819	205154
35-39	151786	181515	0.018	194978	189738
40-44	125427	148448	0.017	158799	154531
45-49	98541	130115	0.0282	145416	141508
50-54	81152	104987	0.0261	116378	113250
55-59	62384	70861	0.0128	74566	72562
60-64	52094	64215	0.0211	69819	67943
65-69	31846	44587	0.0342	51012	49641
70-74	22924	32622	0.0359	37566	36557
75+	21982	37437	0.0547	46323	45078
Total	1986279	2219538	0.0112	2332051	2269379

$P_{03}=p_{01}*(1+r_{0191})^2=2269379$

Table 2: Estimation of five yearly age group through differential distribution method

Age group	1991 census (a_{i91})	2001 census (a_{i01})	Difference ($d_{i0191})=(a_{i01}-a_{i91})$	Difference proportion $P_{i0191}=(d_{i0191}/D_{0191})$	Estimated growth by 2003 $g_{i0301}=(D_{0301}*p_{i0191})$	Estimated population growth by age group $a_{i03}=a_{i01}+g_{i0301}$
1	2	3	4	5	6	7
0-4	167407	156443	−10964	−0.047	−2343	154100
5-9	191025	174686	−16339	−0.07	−3491	171195
10-14	195524	200575	5051	0.0217	1079	201654
15-19	198581	216803	18222	0.0781	3894	220697
20-24	216844	231618	14774	0.0633	3157	234775
25-29	200616	226999	26383	0.1131	5637	232636
30-34	168146	197627	29481	0.1264	6299	203926
35-39	151786	181515	29729	0.1275	6352	187867
40-44	125427	148448	23021	0.0987	4919	153367
45-49	98541	130115	31574	0.1354	6747	136862
50-54	81152	104987	23835	0.1022	5093	110080
55-59	62384	70861	8477	0.0363	1811	72672
60-64	52094	64215	12121	0.052	2590	66805
65-69	31846	44587	12741	0.0546	2722	47309
70-74	22924	32622	9698	0.0416	2072	34694
75+	21982	37437	15455	0.0663	3302	40739
Total	1986279	2219538	233259	1	49841	2269379
	$D_{0191}=\sum(d_{i0191})=233259$		$P_{03}=2269379$	$P_{01}=2219538$		$D_{0301}=p_{03}-p_{01}=49841$

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

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

Age group	1991 census (a_{i91})	2001 census (a_{i01})	Growth rate 1991-2001 (r_{i0191})=$(a_{i01}/a_{i91})^{1/10}-1$	World standard population (W_i)	Adjusted population growth (d_{i0191})=(a_{i01}-a_{i91}+W_i)	Adjusted population growth proportion P_{i0191}=(d_{i0191}/D_{0191})	Estimated growth by 2003 g_{i0301}=(D_{0301}*p_{i0191})	Estimated population growth by age group a_{i03}=a_{i01}+g_{i0301}
1	2	3	4	5	6	7	8	9
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	202933
35-39	151786	181515	0.018	6000	35729	0.1072	5344	186859
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	4000	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	40048
Total	1986279	2219538	0.0112	100000	333259	1	49841	2269379
	D_{0191}=∑(d_{i0191})=33259		P_{03}=p_{01}*(1+r_{0191}) 2=2269379		P_{01}=2219538	D_{0301}=p_{03}–p_{01}=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.

Acknowledgments

The author is thankful to Dr. J. D. Sharma, principal investigator of Population Based Cancer Registry (PBCR), National Cancer registry Program (NCRP), Indian council of Medical Research for providing necessary help and writing of the manuscript. The author is also thankful to Dr. Debanjana Barman, Mrs. Arpita Sharma, Mr. J. A. Barbhuiya, Mr. Ranjan Lahon, Mrs. Barsha Deka and Mr. Kamal C. Deka for helping in the preparation of the paper, field work and data entry.

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How to cite this article: Kalita M, Nirmolia T. Denominators: An attempt to adjust for cancer incidence and mortality rates and its role in cancer registries. South Asian J Cancer 2015;4:24-7.

Source of Support: Nil. **Conflict of Interest:** None declared.