

## RESEARCH ARTICLE

# Additive Properties of Crude, Age Specific and Age Adjusted Rates for Cancer Incidence and Mortality

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### Abstract

**Background:** In National Cancer Registry Programme (NCRP) reports, various rates are routinely provided for 50 cancer sites of males and 54 cancer sites of females. Very often, depending on our interest, we wish to see these rates for group of cancers like head and neck cancers, oral cancers, and reproductive cancers. In such a situation, the desired rates are calculated independently from the actual data and reported. The question is can we derive the rates for groups of cancers from the published reports when the data is provided only for the individual sites? **Objective:** In the present paper, an attempt is made to explore the mathematical properties of various rates to derive them directly for the group of cancer sites from the published data when the rates are provided only for the individual sites. **Source of data:** The cancer incidence data collected by two urban Population Based Cancer Registries (PBCRs), under the network of NCRP for the period of 2006-08 was considered for the study purposes. The Registries included were: Bangalore and Bhopal. **Results:** In the present communication, we have shown that the crude rate (CR), age specific rates and age-adjusted rates (AAR) all possess additive properties. This means, given the above rates for individual sites, the above rates can be calculated for groups of sites by simply adding them. In terms of formula it can be stated that  $CR(\text{Site1}+\text{Site2}+\dots+\text{SiteN}) = CR(\text{Site1})+CR(\text{Site2})+\dots+CR(\text{SiteN})$ . This formula holds good for age specific rates as well as for AAR. This property facilitates the calculation of various rates for defined groups of cancers by simply adding the above rates for individual sites from which they are made up.

**Keywords:** Crude rate - age specific rates - age adjusted rate - additive property

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### Introduction

National Cancer Registry Programme (NCRP) of Indian Council of Medical Research, India, is routinely providing Crude Rates (CR), Age Specific Rates (ASR) and Age Adjusted Rates (AAR) for various cancer sites of selected cancer registries of India. The recent report provided the information related to 25 registries of India (NCRP, 2013). In NCRP reports, various rates are provided for 50 individual cancer sites of males and 54 cancer sites of females. Research communications also very often deals with individual cancer sites like breast (Raizada et al., 2013; Park et al., 2014), Cervix (Peltzer and Mafuya, 2014), Ovary (Wang et al., 2014), Lung (Babacan et al., 2014; Luqman et al., 2014), Prostate (Belbase et al., 2013) and Non-Hodgkin Lymphoma (Balasubramaniam et al., 2013). Few communications also attempted to study the cancers as group like Oral cancer (Rao et al., 2013), Head and Neck Cancer (Mishra and Meherotra, 2014), Reproductive cancers (Takiar and Kumar, 2013) and Tobacco Related Cancers (Takiar et al., 2010). In general, for any group of cancers, the desired rates are often calculated independently by pooling the incidence data of individual sites from which they are constituted

and reported. The question is can we derive the rates for group of cancers from the published report or not when the incidence data is reported only for the individual sites? If, it is possible to derive the rates for group of sites from published data then the question is how?

In the present paper, an attempt is made to explore the mathematical properties of various rates to derive them directly for the group of cancers from the published data when the rates are provided only for the individual cancer sites.

### Materials and Methods

The cancer incidence data collected by two urban Population Based Cancer Registries (PBCRs), under the network of NCRP for the period of 2006-08 was considered for the study purposes (NCRP, 2010). The Registries included were: Bangalore and Bhopal. The information provided on Number, Crude Rate and Age Adjusted Rate including Age Specific Rates of the following cancer sites were considered for the present communication: Lip (C00), Tongue (C01-C02), Mouth (C03-C06), Other Oropharynx (C10), Hypopharynx (C12-13), Pharynx Unspecified (C14), Oesophagus (C15),

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Larynx (C32), Lung (C33-C34), Bladder (C67). These sites together constitute Tobacco Related Cancers (TRCs). From the knowledge of individual number of cases for selected sites and the population at risk, noted from the report, the crude rates are calculated for individual sites as well as for the TRC group as a whole. If CR represent the Crude Rate then given CR of Site1=CR1; CR of Site2=CR2 and CR of Site3=CR3; an attempt is made to show that CR of (Site1+Site2+Site3)=CR1+CR2+CR3 or in general CR of (Site1+Site2+Site3+++SiteN)=CR1+CR2+CR3+++CRN.

*Similarly given*

AAR of Site1=AAR1; AAR of Site2=AAR2 and AAR of Site3=AAR3; an attempt was made to show that AAR of (Site1+Site2+Site3)=AAR1+AAR2+AAR3 or in general AAR of (Site1+Site2+Site3+++SiteN)=AAR1+AAR2+AAR3+++AARN.

**Results**

The individual number of cases for selected TRC sites, for the registry of Bangalore, is shown in Table 1. In addition, from the knowledge of population at risk (7219061), the individual CR is calculated for each site. The total number of cases for TRC sites is shown to be 1957. From the knowledge of population at risk, over all CR for TRC is calculated and shown to be 27.109. It can be verified from the table that sum of individual CRs also gives the number like 27.108 which tallies with CR derived from total cases and population at risk.

The individual number of cases for selected Oral cancer sites, for the registry of Bangalore is shown in Table 2. As done before, from the knowledge of population at

**Table 1. Additive Property of Crude Rate (CR) - Bangalore - Males -TRC Sites - (2006-08)**

Sl. No.	Site	No.	CR
1	Lip (C00)	3	0.042
2	Tongue (C01-C02 )	228	3.158
3	Mouth (C03-C06 )	176	2.438
4	Other Oropharynx (C10)	55	0.762
5	Hypopharynx (C12-C13)	250	3.463
6	Pharynx Unspecified (C14)	58	0.803
7	Oesophagus (C15)	369	5.111
8	Larynx (C32)	169	2.341
9	Lung (C33-C34)	493	6.829
10	Bladder (C67)	156	2.161
	Total (TRC)	1957	27.108
	Population=P	7219061	
	Crude Rate=(N/P)*100,000		27.109

**Table 2. Additive Property of CR - Bangalore - Males - Oral Cancers - (2006-08)**

Sl. No.	Site	No.	CR
1	Lip	3	0.042
2	Tongue	228	3.158
3	Mouth	176	2.438
	Total (Oral Cancer)=N	407	5.638
	Population (P)	7219061	
	CR = (N/P)*100,000		5.638

**Table 3. Crude Rate, Age specific rates and Age Adjusted Rate per 100,000 Population by Selected Cancer Sites - Bhopal -Females - (2006-08)**

Age Group	Lip (C00)	Tongue (C01-C02)	Mouth (C03-C06)	Total	Oral Cancer (C00-C06)
<15	-	-	-	-	-
15-19	-	-	0.36	0.36	0.36
20-24	-	-	-	0	-
25-29	-	-	0.41	0.41	0.41
30-34	0.95	0.95	-	1.9	1.9
35-39	0.49	0.98	-	1.47	1.47
40-44	0.72	1.45	8.68	10.85	10.85
45-49	0.9	2.69	6.27	9.86	9.86
50-54	-	6.17	19.76	25.93	25.93
55-59	-	4.2	18.2	22.4	22.4
60-64	-	21.1	37.34	58.44	58.44
65-69	-	2.17	15.2	17.37	17.37
70-74	-	23.14	36.36	59.5	59.5
75+	-	5.98	5.98	11.96	11.96
CR	0.19	1.55	3.61	5.35	5.36
AAR	0.184	2.332	5.475	7.991	7.991

risk (7219061), the individual CR is calculated for each site. The total number of cases for Oral cancer sites is shown to be 407. From the knowledge of population at risk, over all CR for Oral cancer is calculated and shown to be 5.638. Again, it can be verified from the table that sum of individual CRs also gives the number like 5.638 which tallies with CR derived from total cases and population at risk.

For each cancer site of Oral cancer, based on the number of cases and population at risk, the age specific rates are calculated for each cancer site and shown in Table 3. From the age specific rates and using appropriate world population weights (NCRP 2010), AAR for each site is calculated and shown in the table, below.

It can be verified that sum of age specific rates when added for three cancer sites namely, Lip, Tongue and Mouth gives exactly the same rates that are derived for Oral cancer as a group. The same relationship can be shown for CR as well as for AAR.

**Discussion**

In NCRP reports, routinely, age specific rate, CR and AAR are provided for 50 cancer sites in the case of males and for 54 sites in the case of females. Whenever, there is a need to calculate the above rates for group of cancers, it is calculated by carrying out the task at three steps. First, the individual sites are identified for desired group of cancer. Second, the individual number of cases is added for the individual sites to arrive at the number of cases for the group. Third, by dividing the number of cases by population at risk, the crude rate is calculated. For calculation of age specific rates, the individual number of cases for group of sites is identified and then with the help of population at risk, the age specific rates are obtained. For calculation of Age Adjusted Rate, appropriate weightage are used for age specific rates and then by the defined formula it is calculated (NCRP, 2010).

In the present communication, we have shown that

the CR, Age Specific Rates and AAR, all rates follows additive properties. It means, given the above rates for individual sites, the above rates can be calculated for group of sites by simply adding them. This property facilitates the calculation of various rates for defined group of cancers by simply adding the above rates for individual sites from which they are made up of. In past, we have attempted the projected number of cases for various groups of cancers (Takiar et al., 2010). However, it should be noted that above property holds good only for calculation of group rates within the same registry as they have common denominator or as they have the same population at risk. In the case of different registries, the pooled rates cannot be calculated by adding them as they have different population at risk.

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