RESEARCH COMMUNICATION

Risk of Cancer Development in India

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Abstract

Incidence as a measure of risk for development of cancer is a well accepted epidemiological concept which can be precisely defined. The present communication documents an estimate of the current probability of development of cancer for specific age groups as well as for entire life time risk at the India country level for several cancers and "all sites together". The published data on age specific cancer incidence rates from 12 population based registries located at various parts of the country along with the abridged life tables relating to the Indian population formed the basic material for computation. Employing life table methodology for estimates, the current probability (*100) of developing cancer of all sites from 35-64 years is 4.67% in males and 6.55% in females while life time risk was found to be 9.05% and 10.2% respectively. The greater risk in females was mainly due to the high risk of development of cancer of the uterine cervix and breast. When the age-period of 35 to 70+ years were considered, the probability percentage was found to be 9.94 % in males whereas it was 11.6% in females. According to these estimates 1 in 10 men and 1 in 8 women in India can expect develop cancer of any form, in their life span after the age of 35 years. The probability of developing tobacco related cancers from 35 to 70+ years was found to be 4.75% and 2.16% in males and females respectively. Estimation in terms of probability will be useful in evaluating the changes in the disease spectrum as a result of change in mortality experience and population structure over a period of time.

Keywords: Probability - life table - cancer risk - India

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Introduction

Various conventional measures such as crude, age adjusted, truncated and age specific incidence rates are being employed for measuring incidence of a disease in a defined population. In order to have a single synoptic figure to summarise the experience of the population over life time, measures such as cumulative incidence rate (CIR) and cumulative risk (CR) have been suggested. These measures serve as indices to measure the development of disease within a specified time interval or during life time in the absence of other competing risks. However, these indices do not take into account the mortality experience (due to all other causes) of the population. For assessing the change in the risk for development of disease over a passage of time it is crucial to make adjustments for the varying mortality experiences. The risk of development of disease can be more precisely defined through the concept of probability by combining the age specific incidence data of the disease with life table mortality data.

In the present communication an attempt has been made to estimate risk for development of cancers by age, sex & site. The various sites reported are based on the tenth revision of the International classification of diseases (WHO, ICD,1994). A comprehensive assessment of these risk estimates will serve as useful indices for defining the problem of cancer in the country and also for evaluation of national cancer control programme (NCCP) being launched by Government of India.

Materials and Methods

Estimation of pooled incidence rate

The data on occurrence of cancers in India is available from the Population- based cancer registries (PBCR) established in various parts of the country. Although the area and population covered by these registries is small, it gives some idea of the extent of the cancer problem in the country. The Indian cancer registries contribute data for cancer Incidence in five continents (CI5) being published by the International agency for research on cancer (IARC), Lyon, France.

The Volume VIII of cancer incidence in five continents published for the period 1993-1997 contained data for nine (9) Indian Population based cancer registries (PBCRs) viz. Ahmedabad(urban), Bangalore(urban), Chennai(urban), Delhi(urban), Mumbai(Bombay)(urban), Nagpur(urban), Karunagapally(rural), Pune(urban) and Thiruvananthapuram(rural and urban both) (Parkin, et al., 2002). Further, the annual incidence data for Barshi

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& Bhopal registries were estimated from the two-year period, data relating to the years 1997-1998 (NCRP, 2002). Annual incidence data of cancer was also obtained for the year 1997 from the published report of Kolkatta population based cancer registry (CNCI, 2001). The annual incidence data of the above 3 PBCRs were combined with the data of above 9 registries to get pooled annual incident number of cases of cancer for 12 registries located in different parts of the country. The annual populations of all the above 12 registries by age and sex in the respective five- year age groups were added-up to obtain the total population for all the registries. The pooled age specific incidence rates of cancer by site, age and sex for all the twelve registries were obtained by dividing the respective pooled number of cases with the corresponding pooled population.

Life table data at the national level

The Sample Registration System (SRS) is the main source of information on fertility and mortality in India. The SRS mechanism involves collection of data through two independent methods, viz., continuous enumeration and retrospective surveys followed by a process of matching of the two records and field verification of the unmatched and partially matched events. This process ensures a crosscheck of the correctness and completeness of the recording of births and deaths from the two methods. The abridged life tables for the year 1999-2003 being published by the Registrar General of India, based on SRS was utilized for getting the all causes mortality and the expectation of life at various age intervals by gender and residential status (SRS, 2006).

Estimation of current probability of developing cancer

The probability of development of cancer was estimated using the methodology suggested by Zdeb (1977) and Juneja et al (1988, 1990). Employing the above methodology the probability of developing cancer at the national level was computed by combining the pooled age-specific incidence rate of cancer obtained for all the twelve registries with the cohort population based on abridged life tables relating to Indian population published by the Registrar General of India based on Sample Registration Scheme. Life table data exclusively for the cities of these 12 PBCRs are not available. It was assumed that life tables for the country represent these urban and rural areas. The probabilities have been worked out for different age groups of the cohort such as (i) zero to till the end of life span which represent the life time risk, (ii) 35-64 years, corresponding to truncated period and (iii) 35+ till end of life span.

Results

The estimates of current probability of development of cancer for India have been estimated based on data of earlier established 12 PBCRs in the country. The pooled estimates of cancer incidence for these 12 PBCRs (crude rates & age standardized rates) were found to be 66.38 & 109.8, and 76.08 & 115.2 per 100,000 populations for males and females respectively.

The current probabilities of development of cancer for each site, "all sites", and tobacco related cancers between indicated ages are presented in tables No.1and 2. It was observed that current probability (percentage) of developing cancer of any form in males and females for the cohort of population passing through from zero years to entire life span was 9.05% and 10.2% for males

Table 1. Current Probability (%) of Development of Cancer of Various Sites and "All sites" based on Pooled Incidence of 12 PBCRs for Males

Site Age groups (Years)	0+	35-64	35+
Lip	0.03	0.02	0.03
Tongue	0.46	0.29	0.52
Mouth	0.45	0.29	0.50
Salivary glands	0.04	0.02	0.05
Tonsil	0.12	0.08	0.14
Oropharynx	0.09	0.05	0.10
Nasopharynx	0.04	0.03	0.04
Pyriform sinus	0.00	0.00	0.00
Hypopharynx	0.40	0.22	0.46
Pharynx unspecified	0.11	0.05	0.13
Oesophagus	0.63	0.33	0.72
Stomach	0.50	0.27	0.57
Small intestine	0.02	0.01	0.02
Colon	0.21	0.11	0.23
Rectum	0.21	0.10	0.23
Anus	0.04	0.02	0.04
Liver	0.25	0.13	0.28
Gallbladder	0.11	0.06	0.12
Pancreas	0.15	0.08	0.17
Nasal cavity and middle ear	0.06	0.03	0.06
Accessory sinuses	0.00	0.00	0.00
Larynx	0.57	0.31	0.65
Lung	0.99	0.53	1.13
Other respiratory[1]	0.02	0.01	0.02
Bone	0.07	0.03	0.05
Melanoma of skin	0.03	0.01	0.03
Other skin	0.13	0.06	0.14
Mesothelioma	0.01	0.00	0.01
Kaposi sarcoma	0.00	0.00	0.00
Connective and soft tissue	0.09	0.05	0.08
Breast	0.05	0.03	0.05
Penis	0.11	0.06	0.12
Prostate	0.54	0.11	0.62
Testis	0.05	0.03	0.04
Other male genital organs	0.01	0.00	0.01
Kidney	0.12	0.07	0.13
Renal pelvis	0.00	0.00	0.00
Bladder	0.34	0.14	0.39
Other urinary organs	0.00	0.00	0.00
Eye	0.01	0.00	0.01
Brain, central nervous system	0.23	0.14	0.21
Thyroid	0.07	0.04	0.07
Adrenal gland	0.01	0.00	0.01
Other endocrine	0.00	0.00	0.00
Non-Hodgkin lymphoma	0.00	0.00	0.00
Hodgkin disease	0.07	0.04	0.05
Immunoproliferative diseases	0.29	0.14	0.29
Multiple myeloma	0.10	0.05	0.11
Lymphoid leukaemia	0.09	0.03	0.06
Myeloid leukaemia	0.12	0.06	0.10
Leukaemia, cell unspecified	0.03	0.01	0.02
Other and unspecified	0.91	0.47	1.01
All sites	9.05	4.67	9.94

[1]plus intrathoracic organs

Table 2. Current Probability (%) of Development of Cancer of Various Sites and "All sites" based on Pooled Incidence of 12 PBCRs for Females

Site Age groups (Years)	0+	35-64	35+
Lip	0.02	0.01	0.02
Tongue	0.18	0.10	0.21
Mouth	0.39	0.23	0.46
Salivary glands	0.03	0.02	0.03
Tonsil	0.03	0.01	0.03
Oropharynx	0.02	0.01	0.02
Nasopharynx	0.02	0.01	0.02
Pyriform sinus	0.00	0.00	0.00
Hypopharynx	0.10	0.07	0.12
Pharynx unspecified	0.02	0.01	0.02
Oesophagus	0.53	0.27	0.63
Stomach	0.31	0.18	0.37
Small intestine	0.01	0.01	0.01
Colon	0.20	0.10	0.23
Rectum	0.17	0.10	0.20
Anus	0.03	0.02	0.04
Liver	0.13	0.06	0.15
Gallbladder	0.30	0.18	0.35
Pancreas	0.11	0.06	0.13
Nasal cavity and middle ear	0.04	0.02	0.05
Accessory sinuses	0.00	0.00	0.00
Larynx	0.09	0.05	0.10
Lung	0.28	0.14	0.33
Other respiratory[1]	0.02	0.01	0.02
Bone	0.06	0.02	0.05
Melanoma of skin	0.01	0.00	0.01
Other skin	0.12	0.06	0.14
Mesothelioma	0.00	0.00	0.00
Kaposi sarcoma	0.00	0.00	0.00
Connective and soft tissue	0.08	0.05	0.08
Breast	2.12	1.60	2.46
Vulva	0.04	0.02	0.05
Vagina	0.06	0.04	0.07
Cervix uteri	1.91	1.48	2.23
Corpus uteri	0.24	0.16	0.28
Uterus unspecified	0.07	0.04	0.08
Ovary	0.54	0.39	0.61
Other female genital organs	0.02	0.01	0.03
Placenta	0.01	0.00	0.00
Kidney	0.07	0.04	0.07
Renal pelvis	0.00	0.00	0.00
Bladder	0.11	0.04	0.13
Other urinary organs	0.00	0.00	0.00
Eye	0.01	0.00	0.01
Brain, central nervous system	0.16	0.09	0.15
Thyroid	0.15	0.09	0.15
Adrenal gland	0.01	0.00	0.00
Other endocrine	0.00	0.00	0.00
Non-Hodgkin lymphoma	0.00	0.00	0.00
Hodgkin disease	0.04	0.02	0.03
Immunoproliferative diseases	0.21	0.12	0.24
Multiple myeloma	0.08	0.05	0.10
Lymphoid leukaemia	0.06	0.02	0.04
Myeloid leukaemia	0.11	0.07	0.10
Leukaemia, cell unspecified	0.01	0.00	0.01
Other and unspecified	0.71	0.38	0.82
All sites	10.2	6.55	11.6

[1]plus intrathoracic organs

and females respectively. However, when the current probability of development of cancers over different age groups viz. entire life span of 0+ years, truncated age group of 35-64 years and 35+ years were considered, it was noted that highest current probability was observed with 35+ years. The types of cancers with comparatively higher life time probability among males were observed to be lung cancer (0.99%), oesophagus (0.63%), larynx (0.57%) and prostrate (0.54%). Among females cancer of breast (2.12%), cervix(1.91%) and ovaries(0.54%) were those with higher probability for cancer development.

Table 3. Current Probability (%) of Development of Tobacco-related Cancers

	Males			Females		
Site Age	0+	35-64	35+	0+	35-64	35+
Lip	0.03	0.02	0.03	0.02	0.01	0.02
Tongue	0.46	0.29	0.52	0.18	0.10	0.21
Mouth	0.45	0.29	0.50	0.39	0.23	0.46
Tonsil	0.12	0.08	0.14	0.03	0.01	0.03
Oropharynx	0.09	0.05	0.10	0.02	0.01	0.02
Hypopharynx	0.40	0.22	0.46	0.10	0.07	0.12
Pharynx[1]	0.11	0.05	0.13	0.02	0.01	0.02
Oesophagus	0.63	0.33	0.72	0.53	0.27	0.63
Larynx	0.57	0.31	0.65	0.09	0.05	0.10
Trachea	0.00	0.00	0.00	0.00	0.00	0.00
Lung	0.99	0.53	1.13	0.28	0.14	0.33
Bladder	0.34	0.14	0.39	0.11	0.04	0.13
All sites	4.06	2.27	4.75	1.82	2.00	2.16

[1]unspecified

Similarly, the current probability (per-cent) for development of malignancy of any form for the cohort of population passing through the ages of 35-64 years for males and females was found to be 4.67% and 6.55% respectively. Cancers with higher probability for development was observed in lung cancer (0.53%) in males and breast cancer (1.6%) and cancer cervix (1.48%) among females. The probability for development of cancer for the cohort of population passing through 35 years of age and till the end of life span was observed to be 9.94% and 11.62% for men and women respectively. According to these estimates that, 1 in 10 men and 1 in 8 women would develop cancer of any form some time after the age 35 years till end of life span. The increased risk in females could be attributed or explained by the higher risk for development of cancer of uterine cervix and breast. The types of cancers with comparatively higher probability among males after 35 years was observed to be lung cancer(1.13%), oesophagus (0.72%), larynx (0.65%), prostrate (0.62%), stomach(0.57%), tongue (0.52%) and mouth (0.50%).

The risk of development of cervical cancer was 2.23% while for breast cancer was 2.46% after the age of 35+ years. Among females in addition to cancer of breast and cervix, oesophagus (0.63%) and ovaries (0.61%) were those with higher probability for cancer development after 35 years of age as compared to other cancer types.

The probability of developing tobacco related cancers (TBCs) from 35 + years for all sites was found to be 4.75% and 2.16% amongst males and females respectively (Table 2, Figure 1). TBCs accounted for 40% and 20% to total cancers, respectively. Amongst TBCs lung cancer alone accounted for more than 20% amongst males.

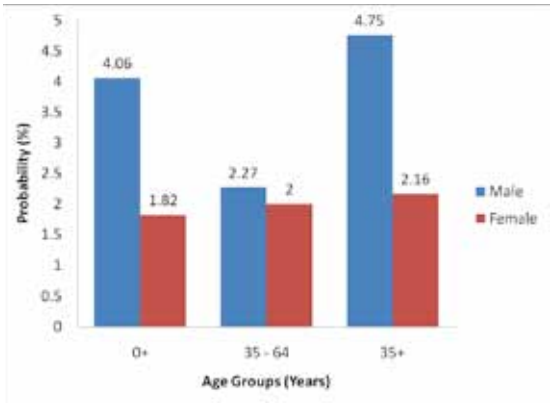

Figure 1. Probability (%) of Development of Tobacco -related Cancer in Various Age Groups

Discussion

The estimates of probability of developing cancer takes care of mortality experiences of the population, whereas the other risk indicators such as cumulative incidence rate and cumulative risk are devoid of such component and is based on cumulating of age specific incidence rates. The present exercise of computing probabilities can be carried out for various periods as well as by age groups to study the changing trends in the disease as a result of changing age structure of the population and also to evaluate any measures taken to prevent or control of cancer.

The present computations highlighted that 1 in 10 men and 1 in 8 women would develop cancer of any form some time after the age 35 years. The highest probability of development of cancer amongst 35+ years indicated that greater proportion of cancers in India occurs beyond the age of 35+ years. Further it was noted that stomach cancer along with lung cancer, was a major problem. Thus smoking related cancers were higher (1.2 folds) among men, while chewing related cancers were found to be higher among women. The probability of developing esophageal cancer were more or less similar among men and women with male to female ratio of 0.9 :1. Among men tobacco related cancers and diet related cancers such as esophagus, stomach, colon & rectum and liver were more common cancers. This indicates that diet may be a more important etiological factor in Indian situation as compared to smoking or chewing habits and consumption of alcohol. Even amongst females cancer of the stomach is also one of the sites with high degree of development of cancer.

Juneja et al (1990) estimated the risk for development of cancer in three urban areas of India and reported that the risk of development of malignancy of all sites from 20-64 years ranged from 4.73% to 5.28% in males, where as it was 6.67% to 9.18% in females. The findings of the present study could not be compared with the above findings due to differences in the age periods considered for estimation of probability of developing cancer. A study carried out by Satyanarayana et al, (2008) was aimed to assess the life time risk for development of ten major cancers in India and its trends over the years 1982 to 2000. However, the life time risk has been estimated only in terms of cumulative risk and no adjustments have been made for mortality experience of the cohort population.

In a study conducted on lifetime and age-conditional probabilities of developing or dying of cancer in Japan the lifetime probability of developing cancer in 2001 has been estimated to be 49.01% for men and 37.36% for women. The lifetime probability of dying of cancer in 2005 was estimated to be 26.59% for men and 16.17% for women. These probabilities mean that one in two males and one in three females developed cancer during their lifetime, and one in four males and one in six females died of cancer. (Katanoda et.al 2008).

It is well known that life styles, age composition of the population and total population size are determinants of cancer magnitude. In addition to age, there is enough evidence to show that cancer share with major key risk factors such as tobacco use (smoking or chewing), unhealthy dietary habits, physical inactivity, alcohol use, infections and behavioral risk factors (Murthy and Mathew, 2004). The interactive, additive and synergistic effects of these factors are responsible for a number of cancer cases and untimely death. Tobacco is one of the single most important risk factor for cancer. The studies carried-out by the National Family Health Survey during the year 1998-99 indicates that tobacco use in any form (smoking or chewing) is prevalent in the country to the extent of 46.5% and 13.8% in males and females respectively. In terms of actual numbers the number of tobacco users in India during the year 1998-99 was estimated to be 149.6 million men and 43.6 million women (IIPS, 2001). There is a strong steady rise in the incidence of life style related cancers in India. Of the total cancer cases nearly 45% and 20 % in males and females are due to tobacco use. Tobacco related cancers account for almost one-third of all cancers in India-predominantly head and neck, lung and esophageal cancers. Spread of tobacco addiction, promoted by commercial interest is responsible for the lung cancer epidemic that is already taking hundreds of thousands of lives annually. Established causes of mouth and pharyngeal cancers are smoking, chewing of tobacco and betel-leaf.

There is evidence that diets high in vegetables and fruits decrease the risk of development of various cancers such as, mouth & pharyngeal, oesophagus, breast, lung, stomach, liver, pancreatic, colorectal, endometrium, prostrate and kidney cancers (WCRF and AICR,1997). Several macro and micro- nutrients have shown convincing modulator effects in prevention of cancer. Recently, the focus and emphasis has been on prevention of cancer through foods of plant origin, which possess anti-carcinogenic and anti-mutagenic properties. Green leafy vegetables, beans of all varieties, cruciferous vegetables such as cabbage, Brussels-sprouts, cauliflower and broccoli are rich in anti-carcinogenic components. Similarly, all the citrus fruits, grapes, apples, strawberries, plums, pineapple, melons have high levels of photochemical which are anti-cancer agents. Cereals, vegetables, fruits, pulses, spice and other plant foods contain many micronutrients such as phytochemicals, vitamins and minerals, which have chemoprevention properties (Ray et al., 2009).

There is a growing awareness that physical inactivity

and lack of physical fitness may be risk factors for several cancers. The evidence is strong for cancer of colon and suggestive for cancer of the prostate and breast. It was estimated from a recent cancer prevention cohort study that over weight and obesity accounted for 14% of all cancer deaths in men and 20 percent of women (Calle et al 2003). The evidence that alcohol increases the cancer risk of mouth and pharynx, larynx, esophagus and liver is convincing and is further increased among drinkers of alcohol who also smoke. Infections with certain viruses are associated with cancer, for example, liver cancer and the hepatitis B virus, and cancer of cervix and the human papillomavirus.

It is important to emphasize that probabilities described in this communication were derived by subjecting the hypothetical life table population into fixed set of age specific cancer incidence rates and mortality from all causes. The probability of developing cancer as described herein should be interpreted chiefly as an index of developing the disease under current conditions of mortality and cancer incidence. The above exercise of computing probabilities can be carried out at various time periods to study the impact of change in mortality experience of population on change in spectrum of disease in population. In developed country like USA this exercise has been carried out at various time periods. It is expected that with the generation of more data on cancer mortality and morbidity, this index will be useful for evaluating recently launched National Cancer Control Programme for the country (2004).

In conclusion, the probability of development of cancer provides an additional useful index in the assessment of cancer problem. The risk of development of cancer in the population can be estimated not only from birth or any other age but also between any two specific ages. As is evident from these findings the risk of eventually developing cancer is not necessarily greatest at birth as indicated by cumulative incidence rate but normally reaches a maximum at later period of life. The probability of developing cancer is based on not only of cancer incidence but also of dying from non cancer cases. Magnitude of the risk of development of disease as a result of change in the mortality experience of the population can be measured by this approach. The other risk indicators such as cumulative risk, cumulative incidence do not take account of mortality experiences.

References

Calle EE, Rodriguez C, Walker-Thurmond K, Thun MJ (2003). Overweight, obesity, and mortality from cancer in a prospectively studied cohort of U.S. adults. *N Engl J Med*, **348**, 1625.

Chittaranjan National Cancer Institute (CNCI) (2001). Population Based Cancer Registry, PBCR, Annual report, Calcutta

Directorate General of Health Services (DGHS), (1984)National Cancer Control Programme for India, Ministry of Health and Family Welfare, Govt. of India

International Institute for Population Sciences (IIPS) (2001). National Family Heath Survey (NFHS-2), India. Mumbai, 1998-99.

Juneja A, Murthy N.S, Prabhakar AK, Sehgal A, Luthra UK (1988). Probability for development of cancer. *Ind J Prev Soc Med*, **19**, 4.

Juneja A, Murthy NS, Sehgal A, Prabhakar AK, Luthra UK (1990). Risk for development of cancer in three urban areas of India. *Neoplasma*, **37**, 483-8.

Kotanoda KKK, Matsuda T, Marugame T, Ajiki W, Sobue T (2009). Lifetime and age-conditional probabilities of developing or dying of cancer in Japan. *Jpn J Clin Oncol*, **38**, 571-576

Murthy NS, Mathew A (2004). Cancer epidemiology, prevention & control - Indian scenario. *Current Sci*, **86**, 518-26,

National Cancer Registry Programme (NCRP). (2002). Two-year report of the population based registries 1997-1998, Incidence and distribution of cancer, Indian Council of Medical Research, New Delhi.

Parkin DM, Whelan SL, Ferlay J. (2002). Cancer Incidence in Five Continents Vol.VIII. International Agency for research on Cancer, IARC Scientific Publication No. 155, Lyon, France.

Ray A, Ray GN, Murthy NS (2009). Cancer chemoprevention and lifestyle factors: an overview of epidemiology and biological mechanisms; In: Arora (Eds.) Herbal drugs: A Cancer Chemopreventive and Therapeutic Perspective, JAYPEE Brothers Medical Publishers (P) LTD, New-Delhi, India.

Satyanarayana L, Asthana S (2008) Life time risk for development of ten major cancers in India and its trends over the years 1982 to 2000. *Indian J Med Sci*, **62**, 35-44.

SRS based abridged life tables, 1999-2003 (2006). Registrar General of India SRS Analytical Report No.1, Registrar General of India, Government of India, New-Delhi.

WCRF and AICR (1997). Food, Nutrition and the Prevention of cancer: A global perspective, World Cancer Research Fund and American Institute for Cancer Research, Washington DC, USA.

WHO International Statistical Classification of Diseases and Related Health Problems-10th revision, 1994, Wrold Health Organization, Geneva.

Zbed MS (1977). The probability of developing cancer. *Am J Epidemiol*, **106**, 6-16.