Cancer epidemiology, prevention and control

N. S. Murthy* and Aleyamma Mathew

Chronic diseases such as cancer, and other non-communicable diseases are fast replacing comm-unicable diseases in India and other developing countries. We deal here with the epidemiology of cancer, its control and prevention measures as applicable to Indian situation. Tobacco is the most important identified cause of cancer followed by dietary practices, inadequate physical activity, alcohol consumption, infections due to viruses and sexual behaviour. Cancer prevention includes primary and secondary prevention measures. Public education on 'tobacco and its health hazards', recommended dietary guidelines, safe sexual practices, and lifestyle modifications form the main features of primary prevention of cancer. Incorporating screening for cancer of cervix, breast and oral cancers into peripheral health infrastructure can have a significant effect on reducing mortality from these diseases.

THE burden of cancer is still increasing worldwide despite advances for diagnosis and treatment. Epidemiological studies have shown that many cancers may be avoidable. It is widely held that 80–90% of human cancers may be attributable to environmental and lifestyle factors such as tobacco, alcohol and dietary habits[1]. Cancer prevention includes primary, secondary and prevention methods. Primary prevention refers to avoiding cancer-causing substances in the environment or dietary elements associated with increased risk; dietary supplementation with putative protective agents. Secondary prevention aims at early detection and removal of benign tumours of oral, cervical and breast cancers[2]. It was estimated that in the year 2000, worldwide over 10 million new cases of cancer occurred (approximately 5.3 million men and 4.7 million women) and over 6 million people died from cancers[3]. The most frequently affected organs are lung, breast, colon, rectum, stomach and liver. Epidemiology of cancer, its control and prevention measures as applicable to Indian population have been discussed here.

Cancer epidemiology

Demographic shift

Urbanization, industrialization, changes in lifestyles, population growth and ageing all have contributed for epide-miological transition in the country. The absolute number of new cancer cases is increasing rapidly, due to growth in size of the population, and increase in the proportion of elderly persons as a result of improved life expectancy following control of communicable diseases. In India, the life expectancy at birth has steadily risen from 45 years in 1971 to 62 years in 1991, indicating a shift in demographic profile[4]. It is estimated that life expectancy of Indian population will increase to 70 years by 2021–25 (ref. 5). Such changes in the age structure would automatically alter the disease pattern associated with ageing and increase the burden of problems such as cancer, cardiovascular and other non-communicable diseases in the society.

Cancer registration: Population-based cancer registry (PBCR) is the source of data in estimating the incidence and mortality as it records all cancer cases occurring in a defined region. The Indian Cancer Society started cancer registration in India by initiating PBCR in the city of Mumbai during the year 1963.

Keeping in view the paucity of reliable data in a country with wide socio-cultural diversity, the Indian Council of Medical Research (ICMR) initiated a network of cancer registration through the National Cancer Registry Programme (NCRP) in 1982 to set up cancer registries in different regions of the country. The ICMR network of registries now consists of 6 PBCRs located at Bangalore, Bhopal, Chennai, Delhi and Mumbai (5 urban) and Barshi (rural). There are some other PBCRs in Kerala (Thiruvananthapuram and Karunagapally), West Bengal (Kolkata), Gujarat (Ahmedabad), and Maharashtra (Pune, Nagpur and Aurangabad), which are not under ICMR. Although the population covered by the above registries is very limited, to the extent of only 5%, it gives some idea of the extent of the cancer problem in the country[6].

N. S. Murthy is in the Institute for Cytology and Preventive Oncology, Maulana Azad Medical College Campus, BSZ Marg, New Delhi 110 002, India; Aleyamma Mathew is in the Division of Epidemiology and Cancer Research, Regional Cancer Centre, Medical College Campus, Thiruvananthapuram 695 011, India
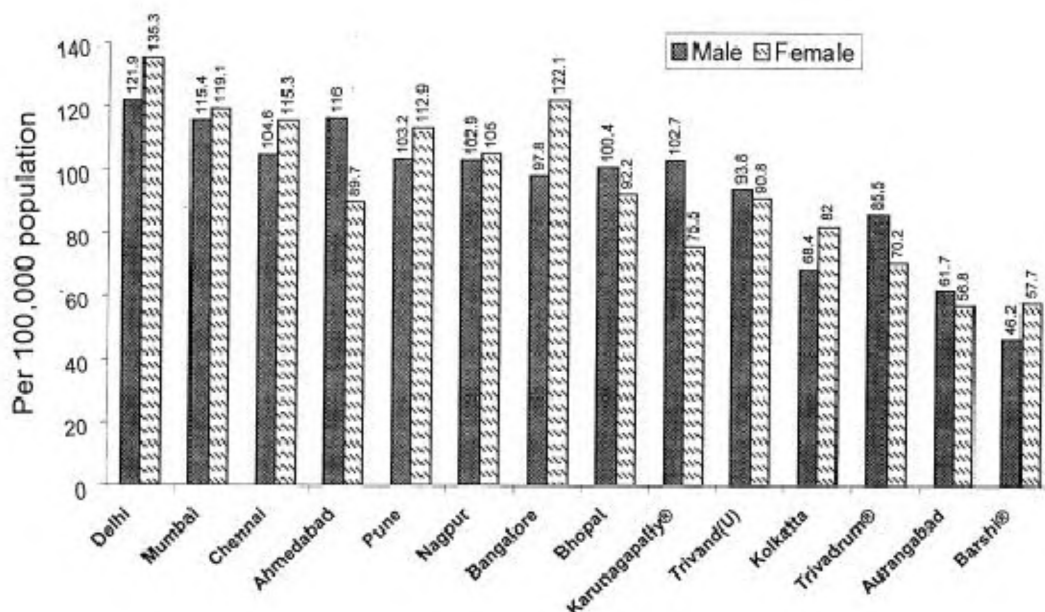*For correspondence. (e-mail: nsmurthy44@yahoo.com)

Figure 1. Age adjusted incidence rates of all cancers in India. (Sources: Refs 7–9).

Magnitude of the problem: Cancer incidence and mortality: From the population-based registries in India covering 28–30 million population from different parts of the country, the age adjusted incidence rates vary from 44 to 122 per 100,000 population in males and 52 to 128 per 100,000 females (Figure 1)[7–9]. Cancer incidence was higher in females compared to males. The incidence in rural areas was quite low compared to urban counterparts. It is estimated that presently nearly one million new cancer cases are being detected annually in the country[10]. The lifetime cumulative risk indicates that an average of one of 10 to 13 people in the urban areas was stricken by cancer during their lifetime[11]. In India, cancer mortality rates are under-reported due to poor recording of the cause of death. The Mumbai cancer registry has reported the age-adjusted mortality rate (AAMR) of 62 per 100,000 males and 58 per 100,000 females. The AAMR per 100,000 populations for males and females in Bangalore was 30 and 29 and in Chennai 62 and 56 respectively[11].

Cancer incidence patterns in different regions of the country

Lung, oesophagus, stomach, oral and pharyngeal cancers are much higher in men while in females the cancers of cervix and breast are predominant forms followed by those of stomach and oesophagus (Tables 1 and 2). There is variation in the sitewise distribution within the various population registries. Oesophageal cancers are often found in the southern states of India such as in Bangalore and Chennai and also in Mumbai and Ahmedabad. Stomach cancers are more common in southern India with the highest incidence in Chennai. Cancers of the oral cavity

are high in Kerala (south India) and pharyngeal cancers in Mumbai (western India). Thyroid cancers among women are more common in Kerala. Gall bladder cancer is high in northern India, particularly in Delhi and Kolkata[7–9].

Trends in incidence rates of cancers in India

Trends in the risk of cancer with time are an important descriptor to understand changes in cancer incidence over a period of time. Data over sufficient duration enabling study of time trends is available only from Mumbai registry where the PBCR has been operating since 1964. Trend analysis of cancer incidence data for the period 1964–96 showed that the overall rates of cancer are increasing with greater increase among females. The largest increase among females was seen for cancer of the breast and among males for cancer of the prostate. Increasing trends were noticed for lymphoma, urinary bladder, gall bladder and brain tumours in both sexes. Cancer of the colon was increasing in females and kidney cancer in males. Oesophageal and stomach cancers were decreasing in both sexes. Cervical cancer showed a decreasing trend[12].

Major preventable risk factors for cancers in India

The major risk factors for cancer are tobacco, alcohol consumption, infections, dietary habits and behavioural risk factors. This offers the prospect for initiating primary and secondary prevention measures for control and prevention of cancers.

Table 1. Age-adjusted (world population) incidence rates (AAR) per 100,000 males of 10 leading cancers in India

Thiruvananthapuram (U)		Thiruvananthapuram (R)		Karunagappally		Bangalore		Chennai		Barshi		Pune	
Site	AAR	Site	AAR	Site	AAR	Site	AAR	Site	AAR	Site	AAR	Site	AAR
Lung	9.0	Mouth	8.0	Lung	19.4	Stomach	10.3	Stomach	15.9	Hypopharynx	6.7	Oesophagus	8.3
Mouth	8.1	Lung	7.7	Mouth	6.8	Oesophagus	8.8	Lung	12.6	Oesophagus	5.8	Lung	7.7
Prostate	6.1	Tongue	5.1	Oesophagus	6.3	Lung	8.1	Oesophagus	10.5	Mouth	3.8	Mouth	7.1
Tongue	5.3	Stomach	3.8	Stomach	5.1	Hypopharynx	5.8	Mouth	7.5	Penis	3.3	Prostate	6.7
Stomach	5.2	Larynx	3.6	Tongue	4.5	H. D. Lymph	5.0	Hypopharynx	6.5	Larynx	2.5	Larynx	6.3
H. D. Lymph	4.8	Oesophagus	3.2	H. D. Lymph	4.4	Prostate	4.7	Tongue	5.8	Rectum	2.6	Stomach	5.4
Larynx	4.3	Prostate	3.1	Liver	3.9	Larynx	4.3	Larynx	5.1	Tongue	2.3	Hypopharynx	4.6
Leukaemia	3.5	Leukaemia	3.0	Leukaemia	3.8	Tongue	3.5	Rectum	3.8	Leukaemia	1.9	Tongue	4.3
Oropha rynx	3.4	Oropharynx	2.8	Larynx	1.7	Leukaemia	3.5	NHL	3.7	Liver	1.8	Brain	4.2
Brain	3.0	Liver	2.4	Ur. Bladder	3.0	Bladder	3.3	Prostate	3.6	H. D. Lymph	1.4	H. D. Lymph	4.2

Mumbai		Kolkata		Aurangabad		Nagpur		Ahmedabad		Bhopal		Delhi	
Site	AAR	Site	AAR	Site	AAR	Site	AAR	Site	AAR	Site	AAR	Site	AAR
Lung	14.5	Lung	17.5	Lung	6.3	Oesophagus	13.3	Lung	10.3	Lung	12.7	Lung	14.0
Oesophagus	10.8	Mouth	7.4	H. D. Lymph	5.1	Larynx	10.0	Oesophagus	10.1	Mouth	10.7	Larynx	9.2
Hypopharynx	8.3	Pharynx	7.0	Tongue	4.8	Lung	7.2	Tongue	10.0	Tongue	7.6	H. D. Lymph	6.9
Larynx	8.2	Larynx	6.9	Hypopharynx	4.7	Tongue	5.2	Hypopharynx	7.7	Oesophagus	6.9	Oesophagus	6.2
Prostate	7.9	Stomach	5.0	Oesophagus	4.5	Leukaemia	4.9	Mouth	6.8	Hypopharynx	6.2	Tongue	6.0
Stomach	7.7	Oesophagus	3.1	Larynx	3.9	Mouth	4.8	Larynx	5.6	Prostate	4.9	U. Bladder	5.8
Tongue	6.5	Tongue	2.9	Mouth	3.3	Stomach	4.8	Prostate	4.8	Larynx	3.8	Prostate	5.7
Mouth	6.2	Prostate	2.6	Leukaemia	2.2	Prostate	3.4	Oropharynx	4.7	Stomach	3.1	Leukaemia	5.5
Bladder	4.8	Bladder	2.4	Brain	1.9	H. D. Lymph	3.4	U. Bladder	3.1	Brain	3.1	Mouth	4.6
NHL	4.1	Hypopharynx	2.2	Pancreas	1.7	Colon	2.7	Rectum	2.8	U. Bladder	2.9	Brain	4.3

Sources: Refs 7–9.

Table 2. Age-adjusted (world population) incidence rates (AAR) per 100,000 females of 10 leading cancers in India

Thiruvananthapuram (U)		Thiruvananthapuram (R)		Karunagappally		Bangalore		Chennai		Barshi		Pune	
Site	AAR	Site	AAR	Site	AAR	Site	AAR	Site	AAR	Site	AAR	Site	AAR
Breast	21.1	Breast	13.9	Cervix	15.0	Cervix	27.2	Cervix	38.9	Cervix	27.4	Breast	26.3
Cervix	11.3	Cervix	12.2	Breast	14.9	Breast	21.3	Breast	23.5	Breast	8.7	Cervix	21.1
Ovary	4.7	Mouth	5.6	Thyroid	5.0	Mouth	8.9	Mouth	8.2	Oesophagus	1.9	Oesophagus	7.4
Thyroid	4.3	Thyroid	4.2	Mouth	3.4	Oesophagus	8.5	Oesophagus	7.0	Ovary	1.2	Ovary	6.8
Mouth	3.7	Ovary	2.9	Ovary	3.0	Stomach	5.1	Stomach	7.0	Rectum	1.1	Lung	4.0
Leukaemia	3.3	Tongue	2.7	Lung	2.9	Ovary	4.3	Ovary	5.7	Skin	1.1	Mouth	3.9
H. D. Lymph	2.8	Brain	2.2	Oesophagus	2.6	Thyroid	3.2	Rectum	2.8			Stomach	3.0
Rectum	2.3	Leukaemia	2.1	Leukaemia	2.0	Leukaemia	2.8	Lung	2.4			Colon	2.7
Body uterus	2.3	Body uterus	1.7	Tongue	1.7	Rectum	2.8	Hypopharynx	2.4			Rectum	2.7
Tongue	2.1	Rectum	1.6	Brain	1.7	H. D. Lymph	2.7	Corpus uteri	2.2			Brain	2.5

Mumbai		Kolkata		Aurangabad		Nagpur		Ahmedabad		Bhopal		Delhi	
Site	AAR	Site	AAR	Site	AAR	Site	AAR	Site	AAR	Site	AAR	Site	AAR
Breast	28.2	Breast	24.7	Cervix	12.7	Cervix	22.4	Breast	21.4	Cervix	21.0	Breast	27.6
Cervix	20.2	Cervix	19.3	Breast	9.7	Breast	22.3	Cervix	15.3	Breast	18.8	Cervix	22.6
Oesophagus	8.3	Gall bladder	7.8	Ovary	4.2	Oesophagus	9.1	Oesophagus	4.4	Ovary	6.1	Ovary	9.0
Ovary	7.2	Ovary	6.1	Oesophagus	2.7	Ovary	6.6	Ovary	4.4	Oesophagus	5.0	Gall bladder	9.0
Mouth	4.6	Lung	4.8	Mouth	2.2	Mouth	3.3	Leukaemia	3.1	Mouth	4.7	Oesophagus	3.9
Stomach	3.8	Oesophagus	2.9	Tongue	2.1	Leukaemia	3.1	Mouth	2.8	Lung	4.1	H. D. Lymph	3.6
Lung	3.7	Corp. ut	2.1	H. D Lymph	2.1	Rectum	2.3	Tongue	2.4	Gall bladder	4.1	Leukaemia	3.4
Colon	3.0	Tongue	1.5	Colon	1.7	Lung	2.3	Lung	2.3	Rectum	2.7	Brain	3.2
Rectum	2.7	NHL	1.5	Leukaemia	1.7	Stomach	2.1	Vagina	2.3	Skin	2.7	Lung	2.9
Gall bladder	2.7	Rectum	1.5	Rectum	1.2			Brain	2.0	Liver	2.0	Stomach	2.4

Sources: Refs 7–9.

Tobacco

Tobacco consumption remains the most important avoidable cancer risk. Between 25 and 30% of all cancers in developed countries are tobacco-related[13]. India is the third largest producer and consumer of tobacco. The country has a long history of tobacco use in a variety of ways of chewing and smoking. The habits of chewing (15–70%) and smoking (23–77%) vary considerably from area to area[13]. It has been estimated that in 1996, 184 million persons used tobacco in the country in one or other form[14]. The cancer risk of tobacco use has been extensively investigated. The principle impact of tobacco smoking is seen in higher incidence of cancers of the lung, larynx, oesophagus, pancreas and bladder. Bidi smoking is associated with cancer of oropharynx as well as larynx[15,16]. Tobacco-related cancers account for nearly 50% of all cancers among men and 25% of all cancers among women. The burden of tobacco-related cancers in India by 2001 has been estimated to be nearly 0.33 million cases annually. These estimates are based on occurrence of cancer of mouth, pharynx, larynx, oesophagus, lung, bladder and pancreas[10]. There are predictions of incidence of 7-fold increase in tobacco-related cancer morbidity between 1995 and 2025. Further there will be an overall increase by 220% of cancer deaths simply related to tobacco use by the year 2025 (ref. 5).

Information on mortality rates associated with tobacco use in India is available from the cohort studies which have been carried out in the country. Applying the median risks of tobacco as obtained from the above cohort studies and the prevalence of tobacco habit as obtained from the first national sample survey showed that about 800,000 persons in India died due to their tobacco habit in 1996 (refs 17–20). Smokeless tobacco users also have a higher risk of mortality. In India, tobacco consumption, which is widespread, is one of the major risk factors for cancer and assumes a very important aspect in all primary prevention of cancer control measures.

WHO has estimated the excess premature mortality attributable to tobacco use amounting to 4 million deaths per year. According to WHO estimates, the annual cigarette consumption per adult in developing countries is on the rise[21]. The WHO has estimated that 91% of oral cancer in this part is directly attributable to tobacco usage[13]. Even for coronary artery disease, cigarette smokers have 70% greater mortality than non-smokers do.

Alcohol

Epidemiological studies carried out in India and abroad have shown that increased alcohol consumption is causally associated with cancers at various sites, mainly oral cavity, pharynx, larynx, and oesophagus[15,22–25]. Heavy alcohol drinkers are frequently heavy smokers as well[12,19–21]. A synergistic effect with cigarette smoking has been suggested. Global results from several case-control and cohort studies indicate that excessive alcohol consumption is responsible for the incidence of primary liver cancer[26]. Several studies have shown an association between alcohol consumption and an increased risk of cancers of colon, rectum and breast[27–29].

Infections

There is strong evidence that majority of cervical neoplasia is caused by certain sub types of human papillomavirus (HPV), a sexually transmitted infection[30]. Studies carried out in India have also confirmed the role of HPV and cervical cancer[31–33]. Besides cervical cancer, evidence indicates that sexually transmitted virus is associated with a variety of other malignancies such as oesophageal carcinoma, anal cancer, penile cancer and oral cancer[34–37]. Other virus–cancer relationships are between Epstein–Barr virus and nasopharyngeal cancer; chronic active infection and hepatitis B virus and primary liver cancer; *Helicobacter pylori* and stomach cancer; HIV and Kaposi's sarcoma and some forms of lymphoma[38,39].

Diet and cancer

Mounting scientific evidences from epidemiological, experimental, clinical/metabolic and intervention studies in the past two decades provide valuable information, which positively suggest role of diet in human cancers. These studies indicate an increased intake of fat and red meat associated with a higher risk of colorectal cancer and probably prostate cancer. High consumption of fruits and vegetables is associated with reduced risk of several cancers including lung, oral, pancreas, larynx, oesophagus, bladder, stomach and cervical cancers[40].

In recent decades, increasing attention has been paid to various foods and their nutrients as modifiers of cancer risk. Doll and Peto[41] have shown the percentage of cancers directly attributable to diet to be approximately 35%. Both laboratory and epidemiological studies support the hypothesis that some dietary components (e.g. high fat intake) can increase the risk of cancer and that others (e.g. high dietary fibre, vitamins C, E and A, and selenium) offer protection against cancer. Persons eating diets high in various micronutrients have been shown to have a lower incidence of certain cancers, especially those of breast, colon and uterus[40].

Dietary and nutritional profile in India

In India, the National Nutrition Monitoring Bureau (NNMB) has been conducting diet and nutrition surveys from 10 states of India since 1972. The nutrition scenario

in India indicates that chronic energy deficiency and deficiencies of vitamin A, folate, riboflavin, iodine and iron are rampant. Highest rates of upper aero digestive cancers are found in India[42–44].

Studies on cancer and diet

The results of various epidemiological studies carried out in the country on cancer and diet have highlighted that intake of vegetables or fruits was significantly low in cases of oral/oropharyngeal and oesophageal cancers. Risk was found to be higher for low intakes of beta-carotene, thiamine, riboflavin, folic acid, iron, magnesium and copper. Other micro-nutritional deficiencies such as vitamins A and E, folate, zinc and selenium were also documented. For nasopharyngeal cancer, though viral aetiology is a well-established causative factor, salted foods and salted fermented fish appear to increase the risk while vegetables and fruits decrease the risk[44,45]. For stomach cancer, though *Helicobacter pylori* infection is an important factor, high consumption of chilli, high temperature food and salted foods were found as risk modifiers[46]. Studies amongst breast cancer patients revealed a higher energy intake and also higher levels of triglycerides and total cholesterol[47]. Studies in precancerous lesions of uterine cervix suggest poor intake of vitamin A, C and E as compared to controls. Lower levels of selenium and folate in plasma were also observed amongst cervical cancer cases as compared to controls[48].

Sexual and reproductive factors

Role of sexual and reproductive factors affecting the incidence of breast and cervical cancers has been well documented from the several epidemiological studies carried out from India as well as other parts of the world. Epidemiological data strongly implicate sexually transmitted agents in the aetiology of cervical cancer[30–32]. Studies carried out have been shown that early onset of menarche, late age at first child birth, nulli-parity and late natural menopause increase the risk of breast cancer[49]. Early age at first sexual intercourse and multiple sexual partners add to the risk of cancer of the cervix[33,50].

Cancer control and prevention in India

Cancer is one of the most important causes of morbidity and the magnitude of the problem is gigantic. Its burden on the economy for providing health care will be substantial. For the treatment of cancer patients, hospitals, beds, sophisticated equipment, machinery, drugs and other health care facilities such as trained nurses, oncologists, large number of hospital days are required. In addition to this, the indirect costs such as loss due to premature deaths, loss due to hindrance of productivity, economic dependence, etc. cannot be quantified. Hence cancer prevention and control is the most appropriate measure.

The Government of India launched the National Cancer Control Programme (NCCP) in 1975–76 to tackle the increasing incidence of cancers in the country. This was later revised in 1984–85 stressing on primary prevention and early detection of cancers. The primary prevention focused on health education regarding hazards of tobacco consumption, genital hygiene, and sexual and reproductive health. Secondary prevention aims at early diagnosis of cancers of uterine cervix, breast and oro-pharyngeal cancers by screening methods. For the purpose of detecting cancer of cervix at an early stage, early cancer detection centres in different medical colleges and postpartum smear testing units in medical colleges in the country have been established. A National Cancer Control Board was constituted at the Centre to operationalize the programme. Similar boards were suggested at the state levels called as State Cancer Control Board (SCCB) for the proper co-ordination of activities. Several states have formulated SCCB.

During the period 1990–91, a demonstration project named district cancer control programme (DCCP) was initiated in selected districts of the country for early detection of cervical, oral and breast cancers at the doorsteps of rural community. The programme created awareness amongst people regarding early symptoms of cancer, importance of observation of personal hygiene and healthy lifestyle, ill effects of tobacco consumption, etc. The project has five components, viz. health education, early detection, training of medical and para-medical personnel, palliative treatment and pain relief and co-ordination and monitoring. The district projects are linked with Regional Cancer Centres (RCC), medical college hospitals having infrastructure for treatment of cancer and the appropriate institutions that supervise and monitor the programme in collaboration with the concerned state governments[5].

The DCCP scheme has been further reoriented on a pilot basis as Modified District Cancer Control Programme. The project has been implemented in the states of Bihar, Tamil Nadu, Uttar Pradesh and West Bengal under the supervision of the state Regional Cancer Centres. Twenty/ten rural blocks from each of the above states have been selected. For each block, 20 female non-communicable workers have been appointed to advice women about healthy lifestyles, ill effects of tobacco and to detect the early symptoms of cancers[51].

Cancer prevention strategies

Primary prevention

The data from the National Cancer Registry Programme showed that one third of the cancers occurring in Indian

population are related to tobacco usage and thus are preventable[52]. The main strategy for control of tobacco-related cancers would be through primary prevention. Tobacco-related cancers such as oral, pharyngeal and lung are mainly amenable to primary prevention programmes. Extensive persuasive health education needs to be directed to control/reduce the tobacco habit. Teen-aged students need to be targeted as most of them pick up habits at this time. The school curricula should involve messages for a healthy lifestyle and warn about the harmful effects of tobacco and alcohol. Appropriate legislative measures need to be taken up for prohibiting sale of tobacco to youngsters, to help in protection of the non-users of tobacco – 'passive smokers' and for stopping advertisements on tobacco. Though there is a ban on advertisement of cigarettes, cigarette smoking is glamorized in various ways. Existing rules and regulations concerning smoking in public places of entertainment and public transport need to be rigidly enforced. In addition to the above, more strategies are needed for control of tobacco-related cancers[53].

There are several core strategies for a comprehensive tobacco-control programme that have the support of the International Agency for Research on Cancer (IARC), the WHO, and the Bureau Against Smoking Prevention and several other international organizations interested in tobacco control[2]. Top priority should be given to control of tobacco; this is likely to have the greatest impact on reducing cancer incidence and cancer mortality compared with any other strategy currently known. Based on the recommendations for Indian situation, the strategies which have been suggested are (i) education of public, (ii) practice of tobacco control and (iii) advocacy for tobacco control. Results of an eight-year primary prevention follow-up study of oral cancer among Indian villagers have shown that through extensive and persuasive health education programme, it is possible to control/reduce the tobacco habits in the community[54–56].

The tobacco control could be achieved by government (including through legislation) and societal actions. It has also been suggested that in terms of tobacco control policies, appropriate health warning labels on cigarette and bidi packets and on all tobacco products, advertisements, warning on smokeless tobacco products, prohibition for smoking in public places, ban on sale of tobacco products to minors, higher taxation on bidis similar to that on cigarettes needs to be adopted. Public education on tobacco and its health hazards, price increase and legislative measures form the main features of primary prevention of tobacco-related cancers[53–57]. Heavy consumers of alcohol should be advised to moderate their consumption and to stop smoking. The impact of this advice could be in the control of cancers of upper respiratory tract[24].

Nutrition education is important for increasing the public awareness, promoting good health and for control of cancers. The recommended dietary guidelines need to be propagated. Dietary intervention for cancer prevention in terms of lowering dietary fat content, increasing intake of fibre, fruits and vegetables is needed to control cancer and other diseases, besides avoiding risk factors such as smoking and alcoholism and exposure to genotoxicants. Public education and awareness about the beneficial effects of consuming plenty of fresh vegetables and fruits with species such as turmeric in adequate amounts to prevent cancer are required. There is a need to popularize the following dietary guidelines for prevention of cancer[43–45].

Dietary guidelines

- It is essential to maintain appropriate weight for height, thus avoiding both under and over-nutrition.
- Physical activity needs to be promoted to avoid obesity and accumulation of fat.
- Intake of protective foods such as vegetables and fruits, preferably fresh, need to be increased to avoid deficiency and protection against environmental insults.
- Plant foods such as cereals, pulses, roots and tubers, green leafy and yellow vegetables, other vegetables/fruits and spices providing nutrients, as well as fibre and protective phytochemicals, should be preferable items in the diet.
- Animal foods (meat and fat) except fish should be curtailed. It is necessary to avoid salted, pickled, smoked and charred food substances.
- Mouldy and damaged foods should be totally eliminated from the diet.

Prospects for the primary prevention of cervical cancer are good as it is related to certain defined risk factors involving lifestyles and behaviour modifications. The development of invasive cervical cancer (ICC) has been strongly linked with early onset of sexual activity and multiple sexual partners. Epidemiological data strongly implicate sexually transmitted agents in the aetiology of invasive cervical cancer. Raising the age at marriage beyond 18 years, observing small family size, adopting safe sexual practices, attention to personal hygiene of both males and females and use of obstructive methods of contraception could help towards primary prevention of ICC. In India, due to absence of any organized mass-screening programme, primary prevention measures assume more importance for prevention of uterine cervical cancer[58]. Prevention of exposure to high-risk Human Papilloma Virus (HPV) types by prophylactic vaccination may prove to be most efficient and feasible option for the prevention of pre-cancerous and cancerous lesions of cervix. Introduction of vaccination against hepatitis B virus into vaccination programme of infants would help in the control of liver cancer[59].

Continuing increased incidence of breast cancer has added urgency to investigations of prevention. It is only

recently that primary prevention of human breast cancer has been discussed as a practical possibility. The following are some of the possible associated actions to prevent invasive breast cancer: (i) Avoidance of breast irradiation particularly in young women, (ii) avoidance of cigarette smoking, active or passive, particularly in adolescence, (iii) to have early first full term pregnancy, (iv) delay in onset of menarche by avoiding over nutrition and by increased physical activity in adolescence, (v) prolonging the duration of lactation, (vi) avoiding obesity especially in postmenopausal women, (vii) prophylactic mastectomy in women with history of breast cancer in first degree relatives[47].

Secondary prevention

Cervical cancer screening. Though cytological examination has been the mainstay for early detection of cervical cancer, its widespread use is not possible in our country due to paucity of resources, manpower and other facilities. Alternative strategies such as naked eye visual inspection of cervix (down staging), visual inspection with acetic acid (VIA), magnified VIA (VIAM), visual inspection with logo's iodine (VIAL), cervicography and HPV DNA testing in detecting cervical cancer and its precursors have to be adopted. The findings from various research studies support the possibility of reducing mortality by earlier clinical detection, followed by basic treatment. This offers a hope for countries with limited resources[58,60].

In India, under district cancer control programme project, in selected districts medical and paramedical staff of the district hospital and anganwadi workers have been trained on the visual examination of the cervix, collection of Pap smears and referring the suspected cases to the district hospital for further evaluation. However, modified district cancer control programme need to be extended to more states and peripheral areas of the country.

Oral cancer screening. Oral cancer satisfies the criteria for screening and oral visual inspection is a suitable test for oral cancer screening. Several studies carried out have indicated that it is possible to train para medical staff to perform the oral cancer-screening test as accurately as doctors[61,62]. Under the district cancer control programme the para-medical staff of the primary health centre have been trained to conduct oral examination for early detection and for providing health education[63].

Breast cancer screening. The model proposed for the control of breast cancer in the country relies mainly on physical examination of the breast by trained female health workers in a primary health care set up and referring the palpable lesions to district hospital/medical colleges/RCT and TC for further evaluation. The use of fine needle aspiration cytology would cut down the cost and

disadvantage of unnecessary biopsies. Breast self-examination could be another effort towards picking up early lesions. Training of existing human resources and health education could be undertaken towards this objective, which would involve minimal funds. In our country, mammography is unlikely to be a cost effective approach to early detection of breast cancer. It is also noted that most of the breast cancer cases in developing countries occur in women below the age of 50 years while the mammography has been found to be effective in postmenopausal women[64,65].

As research advances, leading to proven intervention strategies, it is critical that knowledge about these strategies should be disseminated to the public for improving awareness about the prevention and control measures.

Summary

Non-communicable diseases including cancer are emerging as important public health problems in India. The major risk factors for these diseases are tobacco, dietary habits, inadequate physical activity, alcohol consumption and infections due to viruses. The greatest impact to reduce the burden of cancer comes from primary prevention. Extensive persuasive health education is needed to be directed to control/reduce the tobacco habit. Nutrition education, safe sexual practices, attention to personal and genital hygiene needs to be imported for increasing public awareness. Prophylactic vaccinations against HPV infection and hepatitis B virus are useful strategies for the prevention of cancerous lesions of cervix and in the control of liver cancer. Further, screening for uterine cervix, oral and breast cancers could have a significant effect on reducing mortality from cancer.

1. WHO, The World Health Report, Geneva, 1997.
2. Osborne, M., Boyle, P. and Lipkin, M., Cancer prevention. *Lancet*, 1997, **349** (suppl.), 27–30.
3. Parkin, D. M., Bray, F., Ferlay, J. and Pisani, P., Estimating the world cancer burden: Globocon 2000. *Int. J. Cancer*, 2001, **94**, 153–156.
4. SRS based abridged life tables 1990–94 and 1991–95. *SRS Analytical Studies*, 1998, **1**, 3.
5. National Cancer Control Programme, India: DGHS, MHF and W, Govt. of India, New Delhi, 1996.
6. Mathew, A., Cancer registration with emphasis on Indian Scenario. In *Basic Information for Cancer Registry Documentation* (ed. Mathew, A.), Regional Cancer Centre, Trivandrum, 2003, pp. 11–17.
7. Cancer Registry Abstract, *Newslett. Natl. Cancer Registry Project India*, 2001, **8**.
8. Parkin, D. M., Whelan, S. L., Ferlay, J., Raymond, L. and Young, J., Cancer Incidence in five continents. IARC Scientific Publications, Lyon, 1997.
9. Population based Cancer Registry Report 1991–95, Regional Cancer Centre, Trivandrum, 1999.
10. Murthy, N. S., Juneja, A., Sehgal, A., Prabhakar, A. K. and Luthra, U. K., Cancer projection by the turn of century. *Indian J. Cancer*, 1998, **27**, 74–82.

11. A consolidated study of population based registries data, cancer statistics 1990–96, National Cancer Registry Programme, ICMR, New Delhi, 2000.

12. Yeole, B. B., Trends and predictions of cancer incidence cases by site and sex for Mumbai. *Indian J. Cancer*, 1999, **36**, 163–178.

13. Tobacco costs more than you think, WHO, Geneva, 1995.

14. Report of Expert Committee on economics of tobacco use in India. Ministry of Health and Family Welfare, Government of India, February 2001.

15. Nandakumar, A. *et al.*, A population based case control investigation on cancers of the oral cavity in Bangalore, India. *Br. J. Cancer*, 1990, **62**, 847–851.

16. Sankaranarayanan, R., Duffy, S. W., Padmakumary, G., Day, N. E. and Nair, M. K., Risk factors for cancer of the buccal and labial mucosa in Kerala, Southern India. *J. Epidemiol. Commun. Hlth*, 1990, **44**, 286–292.

17. Gupta, P. C., Health consequences of tobacco use in India. *World Smoking and Health*, Spring, 1988, pp. 5–10.

18. *Tobacco Plain Facts*, Division of non-communicable diseases, Indian Council of Medical Research, New Delhi, India, 1996.

19. Gupta, P. C., Survey of socio demographic characteristics of tobacco use among 99,598 individuals in Bombay, India using hand computers. *Tobacco Control*, 1996, **5**, 114–120.

20. Gupta, P. C. and Mehta, H. C., Cohort study of all-cause mortality among tobacco users in Mumbai, India. *Bull. WHO*, 2000, **78**, 877–883.

21. Control of oral cancer in developing countries. *Bull. WHO*, 1984, **62**, 817–830.

22. Sankaranarayanan, R., Duffy, S. W., Day, N. E., Nair, M. K. and Padmakumary, G., A case control investigation of cancer of the oral tongue and the floor of the mouth in southern India. *Int. J. Cancer*, 1989, **44**, 617–621.

23. Sankaranarayanan, R. *et al.*, Tobacco chewing, alcohol and nasal snuff in cancer of the gingival in Kerala, India. *Br. J. Cancer*, 1989, **60**, 638–643.

24. Sankaranarayanan, R., Duffy, S. W. and Padmakumary, G., Tobacco and alcohol as risk factors in the larynx in Kerala, India. *Int. J. Cancer*, 1990, **45**, 879–882.

25. Monographs on the evaluation of carcinogenic risk to humans: Alcohol drinking, IARC, Lyon, 1988, vol. 44.

26. Jenson, O. M., Painel, S. L., McMichal, A. J. and Ewertz, M., In *Cancer Epidemiology and Prevention* (eds Schottenfeld, D. and Fraumeni, Jr. J. F.), Oxford University Press, Oxford, 1996, 2nd edn.

27. Kearney, J. *et al.*, Diet, alcohol and smoking and the occurrence of hyperplastic polyps of the colon and rectum. *Cancer Causes Control*, 1995, **6**, 45–56.

28. Longnecker, M. P. *et al.*, A meta-analysis of alcohol consumption in relation to risk of breast cancer. *J. Am. Med. Assoc.*, 1988, **260**, 652–656.

29. Longnecker, M. P., Alcohol beverages consumption in relation to risk of breast cancer: Meta-analysis and review. *Cancer Causes Control*, 1994, **5**, 73–82.

30. Ferenczy, A. and Franco, E., Persistent human papilloma virus infection and cervical neaplasia. *Lancet Oncol.*, 2002, **3**, 11–18.

31. Das, B. C. *et al.*, A high frequency of human papillomavirus DNA sequences detected in cervical carcinomas of Indian women as revealed by Southern blot hybridization and polymerase chain reaction. *J. Med. Virol.*, 1992, **36**, 239–245.

32. Murthy, N. S. *et al.*, Risk factors related to biological behaviour of precancerous lesions of uterine cervix. *Br. J. Cancer*, 1990, **61**, 732–736.

33. Murthy, N. S. and Mathew, A., Risk factors for pre-cancerous lesions of uterine cervix – A review. *Eur. J. Cancer Prev.*, 2000, **9**, 5–13.

34. Chang, F. *et al.*, Human papilloma virus (HPV) DNA in oesophagial precancer lesions and squamous carcinomas from China. *Int. J. Cancer*, 1990, **45**, 21–25.

35. Daling, J. R. *et al.*, Sexual practices, sexually transmitted diseases and the incidence of anal cancer. *N. Engl. J. Med.*, 1987, **317**, 973–977.

36. Madden, C. *et al.*, Human papilloma viruses, herpes simplex viruses and risk of oral cancer in men. *Am. J. Epidemiol.*, 1992, **135**, 1093–1102.

37. Madden, C. *et al.*, History of circumcision, medical conditions and sexual activity and risk of penile cancer. *J. Natl. Cancer Inst.*, 1993, **85**, 19–24.

38. Mueller, N. E., Evans, A. S. and London, W. T., Viruses. In *Cancer Epidemiology and Prevention* (eds Schottenfeld, D. and Fraumeni, Jr. J. F.), Oxford University Press, Oxford, 1996, 2nd edn.

39. London, W. T., Primary hepatocellular carcinoma: etiology, pathogenesis and prevention. *Human Pathol.*, 1981, **12**, 1085–1097.

40. *Food, Nutrition and Prevention of Cancer, a Global Perspective*, American Institute for Cancer Research, Washington DC, USA, 1997.

41. Doll, R. and Peto, R., *The Causes of Cancer: Quantitative Estimates of Avoidable Risks of Cancer in United States*, Oxford University Press, New York, 1991.

42. Report of Second Repeat Survey – Rural, National Nutrition Monitoring Bureau, National Institute of Nutrition, ICMR, Hyderabad, 1999.

43. Krishnaswamy, K., Nutrition and cancer in India. *Bull. Nutr. Foundation India*, 1997, **18**, 4.

44. Krishnaswamy, K. and Polasa, K., Diet, nutrition and cancer – The Indian scenario. *Indian J. Med. Res.*, 1995, **102**, 200–209.

45. Krishnaswamy, K. and Prasad, M. R. P., Profile of cancers in India – possible role of dietary factors. In *Diet, Nutrition and Chronic Disease: An Asian Perspective* (eds Shetty, P. and Gopalan, C.), Smith-Gordon, UK, 1995, pp. 61–67.

46. Mathew, A., Gangadharan, P., Varghese, C. and Nair, M. K., Diet and stomach cancer: a case-control study in South India. *Eur. J. Cancer Prev.*, 2000, **9**, 89–97.

47. Love, R. R. and Newcomb, P. A., Prevention of breast cancer. In *Cancer of the Breast* (eds Donegan, W. S. and Spratt, J. S.), WB Saunders Co, 1995, pp. 142–156.

48. Kumar, A., Sharma, S., Murthy, N. S., Das, D. K. and Dutta Gupta, C., Plasma folate, vitamin B_{12} and the risk of cervical intraepithelial neoplasia: A preliminary report. *J. Bas. Appl. Biol.*, 1995, **3**, 23–26.

49. Gajalakshmi, C. K. and Shanta, V., Risk factors for female breast cancer. A hospital based case-control study in Madras, India. *Acta Oncol.*, 1991, **30**, 569–574.

50. Menon, R., Murthy, N. S., Sehgal, A., Prabhakar, A. K. and Luthra, U. K., Role of sexual behaviour in cervical cancer. A case control study. *Indian J. Prev. Soc. Med.*, 1988, **19**, 1.

51. Gupta, S., Rao, Y. N. and Agarwal, S. P., Emerging strategies for cancer control in women of India. In *50 Years of Cancer Control in India*, Director General of Health Services, Govt. of India, 2001, pp. 184–194.

52. National Cancer Registry Programme, Biennial Report 1988–89, Indian Council of Medical Research, New Delhi, 1992.

53. Chaudhry, K., Tobacco control in India. In *50 Years of Cancer Control in India*, Director General of Health Services, Govt. of India, 2001, pp. 196–211.

54. Gupta, P. C., Aghi, M. B., Bhonsle, R. B., Murti, P. R., Mehta, F. S., Mehta, C. R. and Pindborg, J. J., Intervention study of chewing and smoking habits for primary prevention of oral cancer among 12,212 Indian villagers. In *Tobacco: A Major International Health Hazard* (eds Zaridze, D. G. and Peto, R.), International Agency for Research on Cancer, Lyon, 1986, pp. 307–318.

55. Gupta, P. C. *et al.*, Intervention study for primary prevention of oral cancer among 36,000 Indian tobacco users. *Lancet*, 1986, **1**, 1235–1238.

56. Gupta, P. C., Mehta, F. S., Pindborg, J. J., Daftary, D. K., Aghi, M. B., Bhonsle, R. B. and Murti, P. R., A primary prevention

study of oral cancer among Indian villagers. Eight year follow-up results. In *Evaluating the Effectiveness of Primary Prevention of Cancer* (eds Hakama, M., Beral, V., Cullen, J. W. and Parkin, D. M.), International Agency for Research on Cancer, Lyon, 1990.

57. Boyle, P., Global burden of cancer. *Lancet*, 1997, **349**, 23–26.
58. Murthy, N. S. and Mathew, A., Screening for cancer of uterine cervix and approaches adopted in India. *Indian J. Cancer*, 1999, **36**, 154–162.
59. Pandey, M., Mathew, A. and Nair, M. K., Cancer vaccines: a step towards prevention and treatment of cancer. *Eur. J. Surg. Oncol.*, 1999, **25**, 209–214.
60. Sankaranarayanan, R., Shyamalakumary, B., Wesley, R., Sreedevi Amma, N., Parkin, D. M. and Nair, M. K., Visual inspection with acetic acid in the early detection of cervical cancer and precursors. *Int. J. Cancer*, 1999, **80**, 161–163.
61. Nair, M. K., Varghese, C., Mathew, B. and Sankaranarayanan, R., Prevention and early detection of oral, breast and cervical cancer: a practical approach in Indian context. *Indian Med. Assoc.*, 1993, **91**, 94–96.
62. Sankaranarayanan, R., Mathew, B., Binu, J. J., Thomas, G., Somanathan, T., Pisani, P., Pandey, M. and Ramdas, R., Early findings from a community-based cluster randomized controlled oral cancer screening trial in Kerala, India. *Cancer*, 2000, **88**, 664–673.
63. Mathew, B., Sankaranarayanan, R., Sunilkumar, K. B., Kuruvila, B., Pisani, P. and Nair, M. K., Reproducibility and validity of oral visual inspection by trained health workers in the detection of oral pre-cancer and cancer. *Br. J. Cancer*, 1997, **76**, 390–394.
64. Mitra, I., Screening for breast cancer in India. *Nat. Med. J. India*, 1993, **6**, 101–104.
65. Mitra, I., Early detection of breast cancer in industrially developing countries (Suppl.). *Gan. To Kagaku Ryoho*, 1995, **3**, 230–235.